IBU INTERNATIONAL JOURNAL OF TECHNICAL AND NATURAL SCIENCES

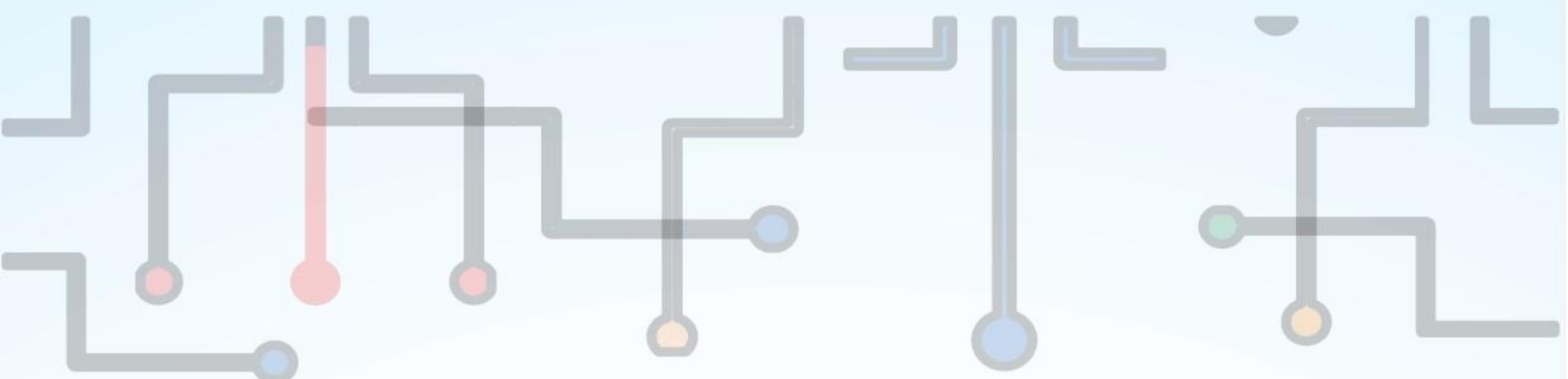**International Balkan University**

Faculty of Engineering

IBU INTERNATIONAL JOURNAL OF TECHNICAL AND NATURAL SCIENCES

TABLE OF CONTENT

INCORPORATION OF CULTURAL FUNCTIONS IN ARCHITECTURAL ADAPTATION FROM TRADITIONAL HISTORIC BUILDINGS INTO ART GALLERIES IN SKOPJE, N. MACEDONIA

Associate Professor PhD. Sc Viktorija Mangaroska

International Balkan University, Faculty of Engineering / Architecture

Abstract. *Architectural adaptation and reuse of historic buildings is a process of changing the original function of the historic buildings to another function that can optimize the use of existing historic buildings. Historic buildings contribute to the character and vitality of the cities. They need to be conserved or adaptively reused in order to form the cultural heritage of tomorrow. Architects have a responsibility to future generations to enrich and preserve the historical buildings, to understand the significance of a place and respond to it. Adaptation projects link the past to the present and project into the future. Heritage items are a response to their cultural, social, historical, political, economic and physical environments. Adaptation or reuse offers new uses for historical buildings. The new use needs to be compatible with the building, retain its historic character, but it can still introduce new services, as well as modifications and additions. Specific attention in this research will be given to historic buildings that will have adaptation and reuse in order to efficiently have architectural space distribution in an art gallery context. Priority should be given to the halls with permanent and temporary art collections, collection repositories and adequate public access and architectural space. Preservation of the collection following, a group of demands associated with the preventive preservation of collections, which are equally important, though with more rigorous solutions demanding higher conciliation levels among architects, restorers and art gallery executives: climate conditions, capacity of the architectural space, light conditions, fire control aesthetic and energy-efficiency issues, that will be examined. This research is conducted to gather and evaluate the conditions of the applied architectural adaptation and re-use principles in selected cultural heritage buildings in Skopje. This research has started with an inventory that led to the discovery of the applied principle of adaptive re-use of historic buildings Daut Pasha hammam and Cifte hammam, which had been adapted in art galleries in Skopje, Macedonia. Results of the case studies carried out showed that the level of architectural conservation of heritage objects is moderate and measures of control should be taken to ensure the privileges of the cultural heritage building. As a result of this research, a number of suggestions are made to ensure that adaptive re-use work in the future needs to be conducted according to the adaptive re-use and conservation principles.*

Keywords: architectural adaptation and reuse; historic buildings.

1. ARCHITECTURAL ADAPTATION OF HISTORIC BUILDINGS – PROCESS AND ORGANIZATION

Architectural adaptation and conservation is process of planned interventions over historical integrity of architectural built heritage. Decisions about the intervention are critical for conservation-restoration of cultural heritage. The decision is value based in combination of artistic, contextual, and informational values. In a process of architectural adaptation and re-use of historic buildings, architects have responsibility to future generations to preserve historical buildings and to understand the significance of a place. Adaptation projects link the past to the present and project into the future. Adaptation or reuse offers new uses for historical buildings. The new use needs to be compatible with the building, retain its historic character, but it can still introduce new functions. The new use needs to be compatible with the building, retain its historic character and conserve significant fabric, but it can still introduce new services, as well as modifications and additions. The adaptation and reuse of historic buildings is a challenging task for the architect and the investor, which consists of complex tasks and problems that need to be solved in order to make the realization of the transformation of the old functions and objects in new modern functions and conditions.

2. CASE STUDY – RESEARCH OF ARCHITECTURAL ADAPTATION STRATEGIES IN HISTORIC BUILDINGS IN SKOPJE, MACEDONIA

Architectural adaptation strategies of architectural historic buildings with cultural heritage in Skopje, Republic of Macedonia, have been selected as case studies:

- *Daut Pashin Hammam, Skopje, Macedonia*
- *Cifte Hammam, Skopje, Macedonia*
- *Suli Inn, Skopje Old Bazaar, Macedonia*
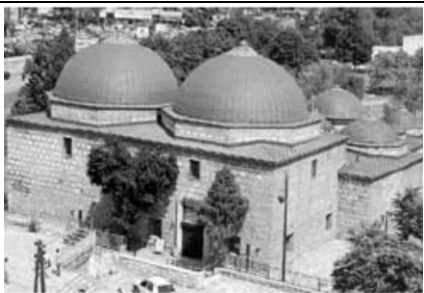
The research has started with an inventory analysis that led to the discovery of adaptation principles of historic buildings in Macedonia. This research consisted of gathering information and analysis of applied adaptation and re-use principles that has been done in architectural adaptation of buildings with cultural heritage from Ottoman period to national art galleries and museums in Skopje Macedonia.

Results of these case studies carried out show that the level of conservation of heritage buildings is moderate and measures of control should be taken to ensure the privileges of cultural heritage building. As a result of this research, a number of suggestions are made to ensure that adaptive re-use work done in the future need to be conducted as optimum as possible according to the adaptive re-use and conservation principles.
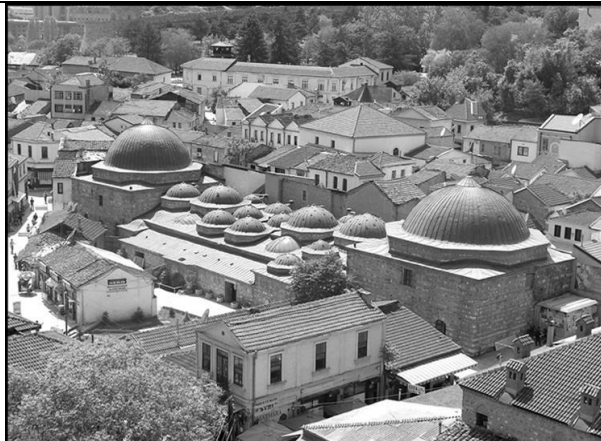
2.1. Case Study Research of Daut Pashin Hammam, Skopje Macedonia

The National Gallery of Macedonia founded in 1948, is one of the oldest art institution of the Republic of Macedonia today, which consists of the exhibition facilities: Daut Pashin Amam, Cifte Amam and Mala Stanica.

2.1 Daut Pashin Hammam, Skopje Macedonia	
Location	Daut Pashin Hammam is located just near the Stone Bridge on the right when standing at the entrance of the Old Bazaar.
Historic Period	It is presumed to have been built in the second half of the 15th century and the founded by the great vizier Daut Pasha who held highest rank in the hierarchy of the Ottoman Empire.
Architectural Type	The hammam belongs to the cifte type of double baths - hammams. It was divided in two parts men's and women's with separate entrances.
	Daut Pashin Hammam has capacity of twelve rooms. It is covered with a large number of domes with different dimensions with fascinating asymmetric and rhythmical arrangement. The domes have rich decoration which consists of stalactite ornaments. In some of the rooms, decoration in

	the shape of a frieze with stylized flowers carved in low relief can be seen in fragments on the walls. Its dimensions and aesthetic values make it a masterpiece of profane Islamic architecture.
Damages over historic periods	This hamam suffered heavy damages in wars, natural disasters, the earthquake of 1555, the fire set to Skopje by Piccolomini in 1689 and the earthquake of 1963.
Function and Re-use	In the past this building was used as a public bath, and since it's restoration in 1948, it serves as an exhibition facility and Art Gallery. Today's permanent exhibition was formed in 2000 with exhibitions of development of Macedonian visual arts from 14th to 20th century

2.2. Case Study Research of Cifte Hammam, Skopje Macedonia

2.2 Cifte Hammam, Skopje Macedonia	
Location	Cifte Hammam is located in the immediate vicinity of Suli Inn in the Old Bazaar in Skopje
Historic Period	Cifte Hamam was built in mid-15th century and is the second-largest hammam from this period, built by Isa Bey in 1531.
Architectural Type	The hammam belongs to the cifte type of double baths - hammams. It was divided in two parts men's and women's with separate entrances. The main rooms are covered with two large domes, while the halvets (bathing cubicles) and other chambers are vaulted with a large number of small domes, today covered with sheet metal. The organization and arrangement of the rooms in both parts is typical and depends on their purpose: the anteroom (meydan or şadrvan) which was intended for relaxation, partially warmed room (kapaluk), bathing space (halvet). Today, the stylized geometric and vegetative ornaments, stalactites and rhombuses rendered with great precision in low relief survive only in fragments in some of the halvets.

Damages over historic periods	Cifte Hamam was damaged several times: in the earthquake which struck the Skopje region in 1555, and during the great fire in the 17th century when the structure was damaged.
	Its full conservation began after the earthquake of 1963, when the bath suffered more extensive damage. Due to the fact that it was solidly built, the hammam mainly preserved its original appearance.
Function and Re-use	Cifte Hamam in 1916 had a function of a storage space. Today it is the site of the National Art Gallery in Macedonia.
	In the past this building was used as a public bath, and since it's restoration in 2002 Cifte Hammam was reopened as a National Gallery, with exhibition area measured of 1056 sq.m.
Preservation Project	New preservation project has started in Cifte Hammam from 2018, which included basic project for remediation of damages from moisture, protection from storm water, ventilation system of interior, protection of UV radiation and repair of the roof construction, conversion of the premises into functional exhibition space, repair of lighting installation. All of the preservation activities of the facility had to be carried out according to the standards and norms from the Conservation approval for repair from the Institute for protection of cultural heritage.

2.3 Case Study Research of Suli Inn, Skopje Macedonia

2.3 Suli Inn, Skopje Macedonia	
Location	Located at the heart of the Old Bazaar in Skopje
Historic Period	Suli Inn was built in the 15th century by Isa-bey
Architectural Type	Suli Inn belongs to the type of two-storey inns with an open square courtyard, surrounded with a porch supported by massive square columns. There are twenty-seven rooms on the ground floor, and thirty rooms with chimneys to keep the visitors warm on the upper floor which served for overnight stay of the travelers. It is built with stone and brick in opus-cloisonné style. Suli Inn represents an important work of profane Ottoman architecture.
Damages over historic periods	In its history, the inn was damaged several times: in the earthquake of 1555 and in the fire of 1689 when the Austrian general Piccolomini set the city of Skopje on fire, and when it was heavily damaged; after these disasters, the inn was reconstructed. In the earthquake of 1963 it was almost completely destroyed, but after its conservation and restoration, it acquired its present-day appearance.
Function and Re-use	It lost its function in the late 19th century; in the period that followed, it served as a warehouse and the site of several craft shops. Today in Suli Inn is located Faculty of Fine Arts, the Gallery of Contemporary Art, as well as of the Old Bazaar opened in 1983 which holds various ceramic works and artworks with motives of the old town, as a unit of the Skopje City Museum.

3. STRATEGIES AND CHALLENGES OF CONNECTING HISTORICAL BUILDINGS WITH THE NEW FUNCTION TO NATIONAL ART GALLERIES AND MUSEUMS IN MACEDONIA

The architectural buildings that are being constructed in particular historical period were built with specific materials and building technologies that followed their function, according to the requirements for their specific function. However, with the development of technology and materials, new approaches in construction materials and building technologies, became more superior and their application has become with more contemporary approach.

Old historic buildings need to be restored according to the technical regulations in terms of cultural heritage regulations, structural stability, seismic analysis of the building, acoustics, thermal protection, moisture protection and fire performance of modern electrical installations, Internet, multimedia presentations. Some of these requests cannot be provided in the historical buildings with the application of the old building techniques.

In the application of new modern interventions in the historical buildings, it is important to be careful and precise not to apply irreconcilable and irreplaceable damages, especially in architectural style, dimensions and silhouette of the form, ambient environment, constructive stability or other harmful interventions.

It is complex and difficult task, to reuse an old historical building, than to build a new architectural building. Modern methods of conservation and protection on historical buildings are applied in Macedonia. Architectural conservation measures were applied in terms of the damage caused to the historical buildings from the earthquake in Skopje in 1963 year. With local assistance and support to the international community in a quality way, many damaged historical objects are being restored.

Strategies of architectural adaptation of historic buildings into art galleries in Macedonia are:

- Preservation of museum and art collections
- Climate conditions
- Building conditions
- Light conditions
- Fire control
- Aesthetic factors,
- Energy-efficiency issues

During the renovation, modern seismic construction techniques and application of modern materials and techniques were used. Adaptation and reuse of historical buildings in Skopje became foundation for their functional adaptation and conversion of their new functional units and organization.

Hammams and Inns are among the most beautiful architectural buildings from the Ottoman cultural heritage in Skopje. Hammams were historic buildings used as public baths in the past. Their adaptation and reuse give them new function into art galleries with permanent and occasional artistic exhibitions. Inns were reused into buildings with cultural and educational function.

It is very important to consider the aspects of the new museological uses from a pre-existing architecture with adaptation of an old historical building, as well as how to display the collection that needs to be preserved.

Museum conception has specific needs that need to be met for the institution to connect with its collection, research, exhibit and educational functions. Therefore, specific attention should be paid for the areas that need to be modified in order to preserve and show the historic value of the building.

- Space distribution – efficient architectural space distribution into context of an art gallery: priority should be given to halls with permanent and temporary collections and adequate public space

-Capacity of the floor construction - the weight of the displayed elements, collection pieces and visiting tourists can exceed bearing capacity of the floors. Structures must be reinforced and they will need intervention on the building.

-Preservation of the collection – priority should be given in preventive preservation of collection, and achieving adequate conditions according to the regulations for preservation of cultural heritage and preservation of museum collections

-Lighting conditions – many collections elements require pale lighting for their preservation. Therefore, some of the original large windows of historic buildings need to have prevention of excessive natural sun light in the museum collection.

-Fire control devices – required infrastructure need to be implemented in order to prevent the impact fire can have on the architectural structure. These plans include evacuation plan and protection of the collections with their classification.

-Climate conditions – museum collections demand specific kind of preservation: relative humidity and temperature. The required equipment for ensuring the museum climate conditions is very expensive, as well as its energy and maintenance costs.

4. BENEFITS OF ARCHITECTURAL ADAPTATION AND RE-USE OF HISTORIC BUILDINGS

Adaptation, conservation and reuse of historical buildings in historical core of the city are important task for every civil society. Old historic architectural buildings bring the spirit of the particular place, called "genus loci", connecting the present function and use, in order to connect the history to the future. Adaptive re-use values are remarkable into keeping the memory and authenticity of the place, because the building has significant meaning in cultural and personal memories over time and history.

Historic buildings contribute to the character and vitality of the cities. They need to be conserved or adaptively reused in order to form the cultural heritage of tomorrow. The selection of appropriate new function is an important factor in determining the success of adaptive re-use of historic buildings.

Benefits of architectural adaptation and re-use of historic buildings in Skopje's Old Bazaar are:

- *Preservation and conservation of historic place*
- *Benefits of keeping the authenticity of historic core of the city*
- *Connecting the art in the city with historic place*
- *Connection between historic buildings in carshija*

Programming a new use for a historic property should be a creative exploration of the relationship between the definition of future needs and historic context.

Adaptation and reuse of old historic buildings into modern and contemporary function – art galleries, has an economic and functional basis. If their function continues according to these principles, it will provide economic basis for the realization of the future functional units in the building.

The application of the Cost-benefit analysis should show which of these conditions and techniques can be realized in the old buildings by defining the positive and negative strains of the application of certain modern requirements and needs. Adaptation and reuse of historic buildings should preserve and conserve the most important character defining features that will be the connection between the past and the future in a unique architectural design with new modern function.

REFERENCES

1. G. Elezovic, Turski Spomenici, kn. X sv. 1 (1348 – 1520), Srpska Kralevska Akademija, Beograd 1940;

2. A. Nikolovski, K. Balabanov, D.]ornakov,,,Suli an", Spomenici na kulturata na Makedonija, Skopje 1980, 48;

3. E. H. Ayverdi, Avrupa'da Osmanlı Mimari Eserleri - Yugoslavya, III. Cild, 3.Kitab, İstanbul 1981,295-296;

4. L. Kumbaraxi-Bogoevi}, Osmanliski spomenici vo Skopje, Skopje 1998,149-151;

5. M. Ozer, Uskup'te Turk Mimarisi (XIV-XIX y.y), Ataturk Kultur Dil ve Tari Yuksek Kurumu, Ankara 2006.

6. Nikolovski, K. Balabanov, D.]ornakov, „Cifte amam", Spomenici na kulturata na Makedonija, Skopje 1980, 49;

7. E. H. Ayverdi, Avrupa'da Osmanlı Mimari Eserleri - Yugoslavya, III. Cild, 3.Kitab, İstanbul 1981, 252;

8. L. Kumbaraxi-Bogoevic, Osmanliski spomenici vo Skopje, Skopje 1998, 169-175;

9. M. Ozer, Uskup'te Turk Mimarisi (XIV-XIX y.y), Ataturk Kultur Dil ve Tarih Yuksek Kurumu, Ankara 2006.

10. E. H. Ayverdi, Avrupa'da Osmanlı Mimari Eserleri - Yugoslavya, III . Cild, 3.Kitab, İstanbul 1981, 299;

11. L. Kumbaraxi-Bogoevic, Osmanliski Spomenici vo Skopje, Skopje 1998; M. Ozer, Uskup'te Turk Mimarisi (XIV-XIX y.y), Ataturk Kultur

12. Dil ve TarihYuksek Kurumu, Ankara 2006

13. Macedonian Cultural Heritage, Ottoman Monuments, Pavlov Z, UNESCO Venice office, Skopje 2008

14. Cultural Heritage in South-East Europe, Macedonia, United Nations Educational, Scientific and Cultural Organization, Skopje 2004

SHOTCRETE AND ITS USAGE

Bulent Suloodja

MSc, geotech. eng., Sector for Urbanism - Municipality of Resen, Resen, R. North Macedonia

Abstract. *Shotcrete is a technique where the concrete mixture is applied to the surface with the help of high pressure and special equipment. The installation can be done through dry and wet mix method. This technique is flexible and has a fast way of installation, but requires good mechanization as well as specialized and well-trained workers. It can be used alone, or in combination with anchors, steel mesh, fiber or other. Shotcreting is widely used in construction especially in: tunnel construction; construction of hydro-technical facilities; slope protection; protection of construction pits; mining; airfields; reconstruction of various buildings, and others. Evidence of the mass and increased application of this technique can be seen in the figures. Thus, in 2019, 4.88[1] billion dollars were spent, and it is predicted that in 2023 this figure will be around 11.5 billion dollars. The biggest consumers of the sprayed concrete technique are the Europeans, but also the built-in quantities in Asian and other countries are not negligible. While in our country this technique is almost new, and it is mostly used in the protection of: slopes in road infrastructure, tunnel construction, hydraulic structures, and similar. There are several examples, but with the announced infrastructure projects it is obvious that this technique will certainly be installed in much larger quantities.*

Keywords*: dry mix method; wet mix method, road infrastructure; shotcrete; tunnel.*

1. INTRODUCTION

Sprayed concrete is a special kind of concrete intended for installation with pressure spraying equipment. There are two methods of installation: the dry mix method, in which a dry mixture of cement and aggregate is transported through a pressure hose, and water is added to the nozzle just before installation, and the wet method, in which the finished concrete mixture is applied directly through the equipment**.**

The basic components of sprayed concrete are: cement, aggregate, water and additives. The quantities of cement range from 300-600 kg/m³, depending on the size of the aggregate, and for the production of sprayed concrete fractions of aggregate from 0-4 mm or 0-8 mm are used, and less often 0-16 mm. The water should be clean and free of chemicals, which should meet the conditions according to PBAB 87(Rulebook on concrete and reinforced concrete). Accelerators are most often used as additives, but in the group of additives can also be included: plasticizers, super plasticizers, antifreeze, aerators, and others. The most used additives are Ingunit-T EKO and Superfluid EKO[2].

Special equipment and a professional team are needed to install the shotcrete. The equipment used in the dry procedure is simpler, only a mixer and a nozzle are used. The mixer transports the dry mixture and water is added directly to the nozzle. While the equipment for the wet method is more modern because the ready mixture reaches the nozzle.

From the team that is involved in the shotcrete technique both professionalism and dedication are required for successful execution of sprayed concrete projects. The number of participants varies depending on the size and complexity of the facility and the procedure used for installation, and that number ranges from 4 to 8 people.

---

[1] www.databridgemarketresearch.com/reports/global-shotcrete-sprayed-concrete-market
[2] https://www.ading.com.mk/

2. APPLICATION OF SHOTCRETE

The shotcrete technique is a specific type of protection for excavations in solid rock masses. This technique has huge potential and a great future. It is constantly evolving starting from the first application. In recent decades, its features are being improved daily and adapted to the needs. It can be used individually or in combination with anchors, steel mesh, fiber or other. There is a wide application in projects like: tunnel construction; construction of hydro-technical facilities; slope protection; protection of construction pits; mining, and others. The shotcrete is also very suitable for the construction of buildings with unusual geometries, such as swimming pools, buildings with a rounded shape and similar buildings. As proof that it is widely used stand the numbers in the reports. According to some research, in 2019 alone, $ 4.88 billion was spent. The largest consumers are the European countries, such as: Germany, Great Britain, Russia, Turkey and others. But the other continents should not be forgotten, America, Australia and Asia are not so far behind European countries.

2.1 SAFETY STABILITY MEASURES

The stabilization of the slopes is necessary even after natural phenomena such as: climate change, humidity, precipitation, freeze-thaw cycles, etc. Such phenomena have become more frequent as climate conditions have changed dramatically globally, especially in recent years. For that purpose, the technique of shotcrete is used as a protective measure. Protection of slopes with shotcrete is mostly applied in the protection of slopes where landslides occur.

In recent years, the use of sprayed concrete to stabilize slopes has significantly increased, both in our country and around the world. The process is simple and efficient and shotcrete can be used alone, but more often in combination with anchors; reinforcement mesh; fibers, or similar. Also, the shotcrete can be combined with other protective measures: with a road net; with gabions; with supporting structures, etc.

Introduction to this technique has been done in the project for protection of slopes on the access road to the dam St. Petka. This example is one of the first usages of shotcrete in North Macedonia. After that facility, shotcreting was used in "Landslide rehabilitation and landslide protection on regional road R-1102, section Veles-Gradsko" in "Protection of slopes on the expressway Prilep-Gradsko" and couple of others.

Figure 1. a) embedded mesh and b) embedded anchors

2.2 REPAIR OF LANDSCAPE AND LANDSCAPE PROTECTION REGIONAL ROAD R1102, SECTION VELES-GRADSKO

At the beginning of 2018, on the regional road R1102, section Veles - Gradsko, a landslide occurred, and activities for reparation were undertaken in February, 2020. Landslide rehabilitation at a place called Cucka, was a combination of several methods for landslide remediation and landslide protection (Figure 2). As part of most methods was the protection of slopes with sprayed concrete in combination with several other protective measures: shotcrete with anchors and paving net; shotcrete with gabions, and others.

Shotcrete protection was used whenever there were possibilities for new landslides. Before starting the construction of the shotcrete, the surface was cleaned, the reinforcing mesh was placed and it was fastened with anchors. At the end of the surface prepared in this way the sprayed concrete was applied in two layers, with a total thickness d = 10-15 cm.

Figure 2. Construction of shotcrete on regional road R1102, section Veles - Gradsko

For successful performance of the shotcrete technique, the order of ubsequent steps that should have been observed was:

1. cleaning the surface that was going to be treated;
2. drilling of holes for placing anchor rods;
3. purification of the hole and placement of the anchor body;
4. injection (watering) of the anchors;
5. placing a base plate and nut;
6. installation of reinforcement mesh;
7. application of sprayed concrete and
8. drilling of short holes for drainage;

All surfaces were properly cleaned using compressed air or water. The anchoring was performed by SN-anchors RA 400/500, with a length of 3÷6 m and a diameter of Ø25 mm, and it was used to secure the unstable rock blocks. The reinforcement was done by placing wire mesh MA 500/560, with a wire diameter of 6 mm and a distance between the eyes of 10 × 10 to 15 × 15 cm. The reinforcement nets were set, ie. separated from the excavation surface, but

did not extend beyond the thickness of the shotcrete. For that purpose, wedges were placed which provided the required position of the net. After the shotcreting was completed, the net was 1 cm covered with the sprayed concrete.

The dry method was also used for embedding sprayed concrete, ie. mix cement, aggregate and accelerator additives, and water was added after in the spraying nozzle. The aggregate grains were not smaller than 10 mm, nor larger than 20 mm, and the dosage of cement and aggregate was in weight ratio from 1:3 to 1:4. The humidity of the unit ranged from 3 to 6%. The application of sprayed concrete was done pneumatically in layers with a thickness of 5 cm on previously prepared surfaces. The applied shotcrete was maintained by wet spraying with water for at least 7 days after the application, i.e until the application of the next layer. While the drainage of the shotcreted surfaces was done by drilling appropriate holes with a diameter Ø50 mm and a length of $0.5 \div 1.0$ m. The forecast distance between the boreholes was 6.0×6.0 m. These holes should have been drilled further after the full completion of the shotcreting.

2.3 PROTECTION OF SLOPES ON THE EXPRESS ROAD PRILEP-GRADSKO

In 2013, a basic project for the construction of the expressway Prilep-Gradsko with a total length of 32.81 km was developed. This project was carried out in several phases, and the construction activities for the realization of the route that passes through Drenovska and Farishka canyons had been started three years ago. Due to the complexity of the terrain, the slope needed protection. As protection measures on slopes several types were envisaged, including protection of slopes with shotcrete technique in combination with anchors, reinforcement mesh, and similar. During the construction of this phase, a total of about 1,000 m³ of sprayed concrete was installed (Figure 2).

For the preparation of this mixture, finely ground Portland cement without additives was used, which was to reach MB30. The grains of the aggregate were with $d_{max} = 16$ mm, while the water satisfied the prescribed requirements according to PBAB 87 (Rulebook on concrete and reinforced concrete). Amounts of accelerator additives ranged from 4-6% of the total amount of mixture. After clearing the surfaces where the shotcrete was to be applied, the reinforcement mesh Q188 (MA 500/560) was placed, with a wire diameter of 6 mm and an eye distance of 10×10 to 15×15 cm. The anchoring was done SN-anchors (RA 400/500), with length L=3-5 m and diameter Ø25 mm, and the placement of the anchors is $a_p/a_n = 2.5 \times 2.5$ m.

Figure 3. Protection of slopes with shotcrete, anchors and reinforced network on the expressway Prilep-Gradsko

3. CONCLUSIONS

Shotcrete is a special concrete intended for installation with pressure spraying equipment. There are two methods of installation: the dry method, in which a dry mixture of cement and aggregate is transported through a pressurized hose, and water is added to the nozzle just before installation. And the second one, a wet method in which the finished concrete mixture is applied directly through the equipment.

The shotcrete technique requires professionalism and dedication for successful execution of sprayed concrete projects. The number of participants varies depending on the size and complexity of the facility and the procedure used for installation.

Shotcreting is a specific type of protection for excavations in solid rock masses that is constantly evolving and improving its properties and adapting to the needs. It is widely used in construction, especially in: tunnel construction; construction of hydro-technical facilities; slope protection; protection of construction pits; mining, and others. The shotcrete is also very suitable for the construction of buildings with unusual geometries, such as swimming pools, buildings with a rounded shape and similar types of projects. The numbers prove that, for example, in 2019 alone, $ 4.88 billion was spent on the installation of shotcrete.

In our country the first step in wide shotcrete usage was made when protecting slopes of the access road to the dam St. Petka. As a continuation of the use of this protection measure are the facilities: "Landslide rehabilitation and landslide protection on regional road R-1102, section Veles-Gradsko"; "Protection of slopes on the expressway Prilep-Gradsko" and many more. Only with these two facilities are installed about 1,200 m^3.

In both elaborated examples, shotcrete was used in combination with reinforcement mesh and anchors, with similar characteristics. The anchoring was done with SN-anchors RA 400/500 and diameter Ø25 mm, while the reinforcement was done by placing wire nets MA 500/560, with a wire diameter of 6 mm and an eye distance of 10 × 10 to 15 × 15 cm.

After the successful projects, the shotcrete received positive reviews from all experts, as well as opportunities for massive application in future. With the announced capital investments in road and railway infrastructure, such as the construction of Corridor 8 and the railway to R. Bulgaria, the future of shotcrete in North Macedonia will be bright. Large quantities of sprayed concrete and application of this technique are projected for installment in several planned facilities with a quantity of over 12000 m³.

REFERENCES

1. Сулооца Булент, *"Технологија и Практична примена на прскан бетон"*, издавачка куќа Јени Балкан, Скопје, Р. Северна Македонија, 2019;

2. ГИМ АД Скопје, *„Основен проект за санација на потпорен sиd и заштита на потенцијално нестабилна зона од одрони на km 49+300"*, Скопје, Р. Северна Македонија, 2019;

3. Простор ДОО Куманово, *„Основен проект за изградба на патен правец А1, Прилеп – Градско"*, Куманово, Р. Македонија, 2013;

4. https://www.marketwatch.com/press-release/shotcretesprayed-concrete-market-share-size-l2021-industry-demand-global-trend-industry-news-business-growth-top-key-players-update-business-statistics-and-research-methodology-by-forecast-to-2027-2021-03-03;

5. https://www.databridgemarketresearch.com/reports/global-shotcrete-sprayed-concrete-market;

6. https://www.ading.com.mk/

NEW CHANGES IN THE POST PANDEMIC ERA IN THE DESIGN OF CAMPUS

Sema Ebibi

International Balkan University, Skopje, Republic of North Macedonia

Abstract. *The global shift to distance learning caused by the pandemic requires rethinking the fundamentals of design for higher education. This milestone moment in global health and human interaction accelerated long-emerging changes in higher education and augmented certain shortcomings and strengths in pedagogical models, causing institutions to reassess existing structures and learning and campus life as they question their visions and goals. New design research on this new normal is required, as the physical space has largely been taken out of the equation of university life. This type of change is something seen in other industries and means for engineers to be more open-minded and creative in their designs. In the past, the purpose of a building was usually clear from the beginning (a hospital is a hospital; a cinema is a cinema), but in the world of tomorrow, engineers must design for agility with a human-centered approach and ensure that developments are resilient. Educators recognize that many formal and informal interactions occur frequently and naturally on campus, promoting cognitive and social development, collegiality, and well-being. Even today's digital natives perceive the inherent value of true interpersonal participation for meaningful experiences. This research study offers new planning and design perspectives to explore how design can support what lies at the center of the campus experience as institutional responses to the pandemic continue to evolve.*

Keywords: *future of campus design; post-pandemic campus; speculative design.*

1. INTRODUCTION

The Covid-19 pandemic has changed everything for the world's population. Its impact has forced people in every industry to flex and evolve in real-time and with long-lasting effects. The way we live, work, learn and even play in times of crisis has changed dramatically. In many ways, the changes are here to stay. These changes can be felt in every field from agriculture to medicine, from ready-made clothing to aviation, from technology travel to automobiles and architecture. As millions of students adapt to online classes, while everyone leaves home and returns to work, professionals work from home and take precautions to stay safe and healthy, as always the word "ordinary" has a new meaning - the world is already changing, fields are changing. Living in social distancing for the foreseeable future affects every move we make and every breath we take. Architecture has always been a way of designing and building how we optimize and interact with the spaces around us; how we live in the world, whether inside or outside; in our homes or public places. This fundamental architectural perspective, which was to design how we as a community interact with our environment and other people around us, and even live our individual lives, may now see a serious overhaul. For practicing architects this has proven to be a huge challenge. In the beginning, perhaps when things stopped completely as people grappled with construction and other architectural projects, and now, as time goes on, the need to envision new approaches to architecture. For young people who want to study architecture, this heralds the beginning of something new and exciting.

2. PUBLIC AND PRIVATE AREAS WILL SEE SERIOUS CHANGES IN DESIGN

Public and private buildings, even open spaces, will no longer be traditionally conceptualized. The world has already begun to adopt new indoor structures. As the coronavirus pandemic spreads around the world, architects and designers are leaving hotels, residential communities, sports complexes, etc., in the future. they accelerated their research and technical skills to identify new patterns that could be incorporated into the design of different spaces. For example, for some activities that are nothing out of the ordinary in a hotel or residential area, there is a major refurbishment and change that we are all witnessing right now. For example, hotels all over the world are abolishing the buffet system. Food is served directly to the table with minimal contact with face masks, globes, and more

precautions. While many schools and universities around the world have yet to reopen, some schools plan to abolish meeting meetings even in the future. In the big picture, areas such as the hall may be missing from the architect's drawings and plans.

As revenues for shopping complexes, restaurants, and hotels around the world continue to decline, their spaces need to be designed to ensure future safety. Architects and interior designers will be asked to submit a blueprint for these plans and processes. In a new future for higher education facilities, one of the most important issues will be how to shape the use of physical space. With the expected changes in the educational process, some of the existing spaces in universities will need to be reused and newly built places will need a different approach in terms of design and purpose. This kind of change is something seen in other industries and means for engineers to be more open-minded and creative in their designs. In the past, the purpose of a building was often clear from the very beginning (a hospital is a hospital; a cinema is a cinema), but in the world of tomorrow, engineers must design for agility with a human-centered approach, developments continue apace. flexible.

3. WHAT HAPPENS WHEN WE BACK TO SCHOOL IN THE SHORT TERM IN THE POST-COVID PERIOD?

Current estimates suggest that it is unlikely that faculty, staff, and students will suddenly return to campus. As institutions assess the potential for "rolling occupancy" on campus to more effectively maintain a safe distance, education leaders need to consider how to apply this approach in physical settings.

To support "rolling occupancy," we will need to create strategies to reduce the density of existing spaces, rethink underutilized space, and incorporate structures to support hybrid installations for digital and physical use. Schools should still rethink how they use their space. While space usage was previously defined for specific purposes, there may now be opportunities to maximize the use of previously underutilized space in brand new ways. Existing underutilized space can be reused to create complementary learning and work environments to ensure safe distance or to be designated as quarantine areas.

Figure 1. To comply with physical distancing, other areas on a campus can be repurposed into educational spaces, including student lounges.

4. IN THE LONG-TERM, WHAT CAN WE LEARN FROM THIS EXPERIENCE THAT WE CAN CARRY FORWARD TO FUTURE-PROOF OUR CAMPUSES?

Educational institutions need to focus on achieving greater physical and mental well-being during the current pandemic and potentially in the future:

1. Lowering densities

2. Optimizing human interaction

3. Providing natural lighting

4. Improving access to air quality

5. Using more exterior spaces

6. Providing concentration spaces

How can we achieve this through strategic design? Some physical and logistical changes may include:

1. Fewer seats and workstations on campus

2. Increasing or creating new virtual tuning styles that make you feel "in the experience"

3. Changing pedestrian access and flow in buildings

4. Limiting the use of basic common items such as fountains and benches

5. Increasing the use of open spaces and lounges for training and meeting purposes

6. Optimizing human encounters to better meet mental, emotional, and cultural needs

Figure 2. Social Distancing in Student Lounge

4.1. Hybrid Higher Education

While lecture halls and indeed many large classrooms will find themselves empty, face-to-face interaction will continue to be a crucial part of higher education. Campus life includes socializing, building relationships, and working collaboratively, and this will continue as part of an education and character-building journey. All this

means that in the near term our university campus designs will be a mix of our familiar campus and new spaces for different uses. The new training facilities will be designed to be more versatile to accommodate flexibility of use. This will allow them to adapt as needed and incorporate modern technology, which has become increasingly important in education. More breakout spaces allow students to collaborate, but most likely in smaller groups.

4.2. Industry Cooperation

Another important factor in how we evaluate the design of our future universities is the reassessment of their purpose and how they serve their communities. While it is easy to imagine how technology or changes in physical domains will affect higher education, it is more difficult to predict how the purpose of universities might change. In these commercial relations, both parties gain. Universities get the much-needed funding, credibility, and opportunity for students to work in real-world project scenarios. Organizations access talent and a wider research pool. An additional advantage in the current environment is that it connects the repurposing of fields in universities; This comes at a time when many companies are considering creating future-proof workspaces and giving their employees more flexibility to work from elsewhere.

4.3. Digital tools: The Key To Future Sustainability

An important question is how to develop a campus that is both versatile and future-proof, with so many possibilities for future university designs. The answer is digital engineering. Powered by domain expertise, digital tools are revolutionizing engineering and design and pushing us into an exciting new future. Using digital technology to design the universities of the future is perhaps the most critical aspect in determining their success, especially given their need to adapt to a new future in a changing world. For example, consider the changing nature of our workplaces. Many of the jobs we saw 10-15 years ago are no longer available.

Figure 3. New Designing in Classrooms

5. WHAT WILL FUTURE EDUCATION SPACES LOOK LIKE?

5.1. Class Occupancy

Educational institutions face the need to reduce classroom sizes, in some cases to 20 to 25 percent of original capacity, to maintain social distancing. To realize these smaller class sizes, schools are considering a hybrid model of online and onsite learning.

5.2. Laboratory Occupancy

Schools are looking for ways to reduce the number of students in lab spaces that require a more hands-on, face-to-face teaching style. For science courses, there may be a transition to virtual simulation software to complement the laboratory curriculum.

5.3. Performing Arts Spaces

Reducing the number of people in performing arts spaces brings with it more challenges. It may take more than a year for these gaps to return to normal. It's difficult to host auditions and group performances while staying away.

5.4. Student service

Institutions are considering what services traditionally offered on campus can now be shifted online. If services are held on campus, considerations are being made for how many students can be served in the same space and by appointment.

5.5. Student Lounges

It is considering removing or reducing the number of chairs and benches in campuses, student halls, and open spaces.

5.6. IT and AV

The increase in online learning has pushed IT and AV departments to make major advances in infrastructure–to support and distribute access–and equipment–to accommodate more laptops, enhanced screens, monitors, recording, and broadcasting. These departments are also considering room configuration–redoing typical classrooms to accommodate virtual learning. This means much better lighting, acoustics, cameras, two-way engagement software, etc.

5.7. Administrative Space

There may be a return to closed offices through open stations. Seating in reception areas, break rooms, and meeting rooms will be monitored.

5.8. Libraries

Libraries are adapting to meet the demand for online resources as well as technology to address growing concerns about cybersecurity and privacy. Institutions identify the best ways to disinfect books, materials, and workspaces.
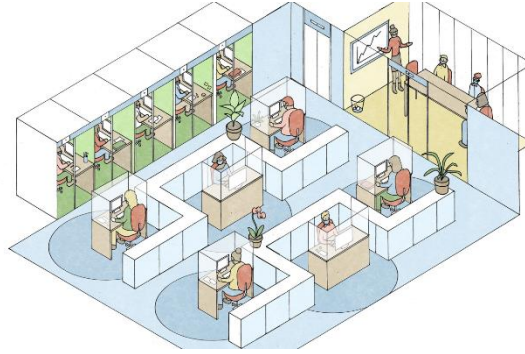
Figure 4. Designing For Higher Education In A Library

6. CONCLUSION

In the future, campuses will not separate learning areas from residential and recreational areas. The mixed-use environment, the key to dynamic urban neighborhoods, will be replicated in the mini-city that functionally makes up most of the closed campuses. The key will be to deliberately redesign the campus model to not only pool the uses to see what happens, but also continue to maximize the factors we know feed these neural networks. But it's time to imagine a different model that creates countless small moments of interaction, bringing people together rather than separating them.

The most important point to remember is that our universities are in a dangerous position and that education contributes significantly to the progress of our societies. By reshaping our universities, we not only have the opportunity to ensure their survival, but we also have the opportunity to position our societies the way we want, with foundations and individuals who will provide an exciting new future.

REFERENCES

1. Dietz, L.; Horve, P.F.; Coil, D.A.; Fretz, M.; Eisen, J.A.; Van DenWymelenberg, K. 2019 Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations to Reduce Transmission. mSystems 2020. [CrossRef] [PubMed]
2. Lippe-McGrow, J. The Future of Design after COVID-19. Available online: https://www.departures.com/ lifestyle/architecture/architects-predict-future-of-design (accessed on 13 September 2020).
   3.Smith,R.;Quale,J.Osite Architecture: Constructing the Future; Taylor & Francis: Abingdon, UK, 2017.
3. Dreessen, T. How COVID-19Will Change the Design of Our Cities. Available online: https://www.obj.ca/ article/sponsored-architects-dca-how-covid-19-will-change-design-our-cities (accessed on 16 August 2020).
4. Tran, T.; Hoang, A.D.; Nguyen, Y.C.; Nguyen, L.C.; Ta, N.T.; Pham, Q.H.; Pham, C.X.; Le, Q.A.; Dinh, V.H.; Nguyen, T.T. Toward sustainable learning during school suspension: Socioeconomic, occupational aspirations, and learning behavior of vietnamese students during COVID-19. Sustainability 2020, 12, 4195. [CrossRef]
5. Megahed, N.A.; Ghoneim, E.M. Antivirus-built environment: Lessons learned from Covid-19 Pandemic. Sustain. Cities Soc. 2020, 61, 102350. [CrossRef] [PubMed].

SUSTAINABILITY PROJECT

Ali Telli

ali.telli@dpu.edu.tr

Lecturer, Kütahya Dumlupınar University Kütahya Technical Sciences Vocational School Civil Defense and Firefighting Program.

Abstract. *Due to the increase of countries that have signed the Kyoto Protocol, there is a worldwide increase of companies that put forward sustainability projects. Countries obeying global principles within the sustainability framework have also tightened the external audits of the companies related to sustainability issues. Realizing that acting solely for profit prevents company growth, organizations are also making efforts to achieve the criteria of environmental sustainability indexes in line with their social responsibilities. In the Stockholm Conference, on June 16, 1972, for the first time, it was alarmed that the world resources have been rapidly depleted, and serious problems could be experienced if soon something will not be changed. Countries that have reached the level of danger were uncertain about further actions. The United Nations report, convened under the chairmanship of Gro Harlem Brundtland, published at the end of 1987, suggested for the first time tangible measures about the steps to cope with the situation. While expressing the activities to be taken in this report titled "Our Common Future" the word sustainability was pronounced and used in the literature for the first time. Sustainability can be defined simply as developing without harming the resources of future generations while consuming today's resources. Following this definition, a demand was imposed to all countries around the world for a joint solution for this issue, which represents a common problem of humanity.*

Keywords: *Sustainability Project; Kyoto Protocol; Natural resources; Reducing wastes harmful for the environment.*

1. INTRODUCTION

Cities that host the majority of the world's population have a key role in satisfying our basic needs and increasing the quality of life. Cities, the areas where we live, have become basic elements that determine our consumption and lifestyles. Hence, what we want to achieve while being residents in the city has become directly related to what kind of life we want to live, and it is related to:

1. Protection of agricultural land

2. Protection of natural and cultural identities

3. Protection of green areas

4. Waste management and environmental protection

5. Adapting to climate change

6. Development of sustainable transport

7. Development of urban infrastructure

8. Healthy development of cities

9. Ensuring active participation of stakeholders in decision-making processes

10. Supporting rural development

11. Creating ecologically literate municipalities

2. PROTECTION OF AGRICULTURAL LANDS

The rapidly increasing population causes construction pressure on the agricultural lands in the periphery of the cities. Due to construction, we are losing our fertile lands, formed in thousands of years, very fast. In addition to this, the Law on the establishment of municipalities in metropolitan cities of the REPUBLIC OF TURKEY Law No. 6360, related to the establishment of new municipalities, many villages and town municipalities will be converted into neighborhoods that will pave the way for urbanization.

However, for newly developed areas, of all kinds of use, the necessary infrastructure is provided. Areas with fertile lands have been offered for construction. But, we know that there is no alternative.

Turkey is not as rich as it seems in terms of agricultural land potential. It has limitations in terms of characteristics and possibilities of the lands:

- The slope of two-thirds of the land across the country is more than 15%.

- Deep lands make up only 14.3% of the total, medium-deep 11.9%, and shallow lands participate with 67.7%.

- Two-thirds (67%) of our soil lacks organic matter.

Severe land erosion of 7.72%, moderate of 20%, severe of 36.4%, and very severe erosion of 22.3%, was observed. Therefore, the provision of fertile agricultural lands that do not have restrictions for crop production is extremely important.

3. PRESERVATION OF NATURAL IDENTITIES

In addition to the physical, socio-economic, cultural, and historical characteristics of the settlements, green areas, natural assets, and ecosystem components are also significant elements that make the urban identity. The natural identity of cities includes natural assets such as green areas, wetlands, forests, water basins, agricultural fields, and ecosystems. Urban identity varies when it is destroyed from the situations when it changed due to construction and pollution reasons. As the memory of the society is of huge importance, during the development and transformation processes of cities, the municipalities are obliged to preserve their natural and cultural identities.

4. PROTECTION OF GREEN AREAS

Green areas that allow integration with nature in a congested urban texture, in constructed settlements, are the places for people to rest, walk around and get closer to nature. In this context, green areas balance the deteriorating relationship between man and nature and improve urban living conditions and quality of life. For example, green designs can be created and not seen with a reserve where they can be open, but they should be continuously maintained and set as reference values.

Following the legislation in Turkey, the required active green area per person in the residential settlements should be 10 m^2. For example, in Istanbul, according to the data of Istanbul Metropolitan Municipality from 2010, calculated green areas per person is 6 m^2. However, green areas included in these calculations, can't be reached. Active green space definition is related to those that are in direct contact with people, such as parks, gardens, children's playgrounds. These are open areas for direct use, like roadsides, shelters, and forests. It does not cover all areas they should, but the features of the users need to be considered as well.

The amount of green space per person in developed countries is as follows: in Stockholm 87.5 m^2, 45.3 m^2 in Rome, 26.9 m^2 in London, and 45.5 m^2 green area in Amsterdam.

5. WASTE MANAGEMENT AND PROTECTION OF THE ENVIRONMENT

For the urban areas, it is essential to establish landfill facilities, systems for waste disposal and waste recycling, wastewater network and systems for wastewater treatment, and in addition to that, the adequacy and correct

operation of the systems. A common situation in the cities located near forests areas is to store solid waste in the vicinity of those areas. This can increase both, the risk of fire and disturbance of the ecosystem in the forest, which is of great importance for public health in the cities. Similarly, if a solid waste storage area or wastewater treatment plant is constructed on agricultural lands, there is a loss of fertile soils.

According to data of the Turkish Statistical Institute (TUİK) 2010, only 54.4% of the collected municipal waste is in landfills, out of which 43.5% is called wild storage area and threatens the environment and human health. Again, if we look at the 2010 data of TUİK, 24% of the wastewater isn't subjected to any purification treatment instead, it is directly discharged into the environment, in the recipients such as the sea, lakes, rivers, etc. 48.6% of the total wastewater is discharged to the rivers, and 32.2% of these is not treated. This situation, together with drought becomes an increasingly serious problem, threatening our resources.

Considering the solid waste disposal methods in the European Union member countries, according to 2009 data, e.g. Switzerland, close to 50% of the solid waste is converted to electrical energy, 30% is recycled and 20% is composted. In Austria, 30% of energy is produced, 30% is recycled, and 40% originates from compost.

6. ADAPTING TO CLIMATE CHANGE

Already we started to see the effects of climate change, which is our biggest common problem in Turkey and all over the world. Due to the human-induced climate change in Turkey, there are significant material losses and financial losses caused by flood damages and earthquakes, respectively. The need to combat and adapt to climate change shows how important local governments are in saving our civilization.

75% of the greenhouse gas emissions in the world originate from the cities due to the electricity generation, heating, the use of fossil fuels in areas such as urban transport, etc. The disappearance of carbon sink areas such as lands is the reason cities to be considered as the most important factor in climate change.

However, more than half of the world's population and approximately 90% of Turkey's population live in urban areas. An increase in droughts and floods due to climate change negatively affects the infrastructure. Damage to infrastructure and extreme climatic conditions (extreme temperatures, extreme cold, floods, hurricanes, etc.) endangers public health. At the same time, if appropriate measures are not going to be implemented, many cities are at significant risk as a result of the rise in the sea level.

As a society, in order to combat and adapt to climate change, the adaptation of transport policies has been made, promoting energy conservation and usage of renewable energy. We demand the development of systems and the use of local authorities in landscaping.

7. IMPROVING SUSTAINABLE TRANSPORT

Policies of transportation, air pollution in cities, traffic problems, climate change, the last in terms of quality of life, is an extremely important issue in terms of sustainability. Building only new roads to satisfy the transportation policies is not enough, but also an establishment of supply-demand balance in transportation, preferences of transportation type, land use are also very significant issues. Fossil fuel is considered to be the primary cause of climate change. Thus, the establishment of appropriate sustainable transport policies is an important part of the fight against climate change.

Considering the preferred modes of transportation in urban areas in European Union member countries (European Metropolitan Transport Authorities, 2011), 68% of transportation methods consist of bicycles and pedestrians, 11% belong to public transport, and 21% involve other motor vehicles. In Barcelona, 55.3% of all types of transportation belong to bicycles and pedestrians, 30.8% to public transport, and 13.9% to other motor vehicles. As can be seen, in the urban areas of the developed countries, people mostly use bicycles, or they prefer walking to their destination.

As a society, we want to develop public transport systems in an integrated way of different modes of transport. We demand planning and encouraging the use of bicycles.

8. DEVELOPMENT OF INFRASTRUCTURE

Solid water networks protect water assets and prevent leakages encouraging innovative solutions such as a separation of sewage water from other streams. Improvement of electricity networks for energy efficiency and savings is also a demand in providing reliable infrastructure.

Firm infrastructure is vital for the healthy development of cities and increasing the quality of life. Cities that have not met their needs such as roads, sewerage, rainwater, and drinking water at a sufficient level, will not provide economic and social development, and they also become a great threat to nature. One of the most important problems in terms of infrastructure is the lack of detailed information about the infrastructure. In many cities, underground maps and routes don't provide evidence about water, wastewater, electricity, and telecommunication networks. For this reason, while construction is carried out, electricity lines, telephone cables, or water networks can be often damaged.

Water losses and water leakages in cities are at high levels. Water network structure losses are estimated to be between 40 and 45%. According to the data of the General Directorate, in 2011 total water network structure loss is 14.6%. According to 2008 data, water network structure losses in European Union member countries is about 6%.

9. HEALTHY DEVELOPMENT OF CITIES

In terms of the health of cities, necessary planning integrating ecological and socio-cultural aspects of living is taking place, and after, these plans need to be realized. Rapid development in almost all cities in Turkey is taking place. As a result, by ignoring ecological and socio-cultural dimensions, we are facing projects that do not comply with initially transformation plans or upper scale plans. With these rapidly developing plans and projects, discussions on urban transformation are also increasing in our country, underlining the need of developing inclusive and solid projects.

10. ENSURING ACTIVE PARTICIPATION OF STAKEHOLDERS IN DECISION PROCESSES

The main stakeholders in decision-making processes are the local governments and NGOs. The decision affects the whole society and individuals. Institutions such as universities need to ensure their active participation in the process of decision-making. With the United Nations Aarhus Convention (2011), "present and future generations", by the access to the information related to the environment where they live, by the provision of the healthy and safe environment, by the participation of citizens in decision-making, and by the possibility to appeal to the judiciary, the rights of the humans are guaranteed. Although Turkey is not yet a party to the Aarhus Convention, local governments apply the environmental democracy understanding of the Convention and ensure that the public and stakeholders can effectively implement the mechanisms of decision making.

11. SUPPORTING RURAL DEVELOPMENT

Increasing poverty and hunger will lead to differences between rural and urban areas, between developed and underdeveloped regions and countries. Economic imbalances and injustices, pollution, and depleting natural resources, make the concept of rural development at the forefront of the agenda in most of the countries in the world. Expanding possibilities for production and marketing opportunities in the regions where urban services will be delivered, the foundation of local seed exchange networks and promoting local producers, by establishing local market systems with possibility for branding, provision of easy and short transportation, will lead to the support and increase in social opportunities in the country. According to data from the Turkish Statistical Institute (TUİK) from 2013, 91.3% of the population in Turkey lives in provincial and district centers. It is an indicator of a need the rural development in Turkey to be supported. Common goals are the approaches implemented in the development of rural areas, following the constant changes in the needs of customers, localization, and empowerment of local communities. In the countries such as Turkey, where a large part of the population lives in cities, one of the goals of the local authorities in the cities in the food supply to the urban areas complying with the sustainability demands.

The idea is, if the food is supplied from the rural regions that are closer to the cities, it will lead to the reduction of the carbon footprint caused by longer transportation.

12. Establishment of Ecologically Literate Municipalities

Ecology literacy is defined as "understanding the natural processes that make life possible on earth or knowledge about nature and understanding nature". Ecology literacy provides the development of consciousness, learning the principles of nature, and communication with nature. Local governments are the most significant decision-making bodies that can create cities in harmony with nature. The task of the administrators in municipalities is to establish sustainable cities in harmony with nature, ensuring that employees understand nature and realize that they are a part of nature. As a society, we strive toward ecologically literate municipalities.

13. RESULTS

Participants in the United Nations Conference held in Rio, Brazil in 1992, rolled up their sleeves to take clear and more tangible steps on sustainability, Figure 1. The presidents /representatives of 178 countries signed the decisions entitled Agenda 21. With this signature, they committed to sustainable development. These 178 countries were primarily involved in the development of all the principles that are put in force later.

Figure 1. Participants in the United Nations Conference held in Rio, Brazil in 1992.
Some participating countries are as follows:Albania, Antigua & Barbuda, Argentina, Australia,
Bolivia, Brazil, Bulgaria, Chile, China, Costa Rica, Denmark, Ecuador, France, Grenada, Haiti, India, Indonesia, Iran, Lithuania, Nepal, Nigeria, Norway, Portugal, Russia, South Africa, South Korea, Spain, Sri Lanka, Sweden, Turkmenistan, Uruguay, Zimbabwes. [2]

Today, the number of countries that have signed the Kyoto Protocol worldwide is 189, Figure 2.

Figure 2. Countries that signed Kyoto Protocol [3]

After the commitments made, all countries have chosen to regulate their laws and procedures. In the light of the regulations made, 3 main strategies (principles) determined are: efficient use of natural resources, reducing wastes harmful to the environment, and making resources reusable.

Recently, the companies preparing sustainability projects have incorporated this innovative principle. This work deals with the historical background of the sustainable development concept. When the fact that countries cannot fulfill the principles they promise independently from companies came to light, especially multinational companies took steps in sustainability as a pioneer. In January 2002, under the leadership of the United Nations, 16 of the world's largest companies promised to create a business plan that will adhere to the principles of sustainability. This promise can be interpreted as a commitment that companies will be subject to the Global Compact. In this context, the content of this article can be summed as follows (as in the hierarchical order of the titles): "The Emergence and the Development of Sustainability Thought", "From Sustainability Thought to Sustainable Development": "The United Nations Environment Programme-The World Conservation Strategy (1980)", "The WCED Report of Our Common Future (1987)", "The 1012 Recep BOZLAĞAN * Yrd. Doç. Dr., Marmara Üniversitesi, Sosyal Bilimler Meslek Yüksek Okulu. United Nations Conference on Environment and Development (Rio de Janeiro, 1992)", "The Fifth Action Programme of European Union (1992)", "The United Nations Conference on Population and Development (Cairo, 1995)", "The United Nations Conference on Human Settlements-Habitat II (İstanbul, 1996)", "Rio+5 Forum (Rio de Janeiro, 1997)" and the World Summit on Sustainable Development (Johannesburg, 2002).

Companies that want to prepare a sustainability project analyze the performances of the actors in the global market well and develop their own strategies in this direction.

REFERENCES

1. https://www.tema.org.tr (Turkish Foundation for Combating Erosion, Afforestation and Conservation of Natural Assets)
2. *https://en.wikipedia.org/wiki/Kyoto_Protocol*
3. https://en.wikipedia.org/wiki/United_Nations_Conference_on_Sustainable_Development
4. Asia-Pasific Councils (1997), "Moving Sustainable Development from Agenda to Action", Asia-Pasific Council News, January-March, s. 2..
5. Karabacak, K. & Telli, A. (2017). Cost Minimization of Hybrid Renewable Energy Sources Using Genetic Algorithm. Yalvaç Academy Journal, 2 (2),41-54. .
6. Firefighting, Mechanics, Maintenance and Repair Book. 2021 Türker Süleyman, Telli Ali Kutlu Yayınevi Basım Yayım Dağıtım Ltd. Şti. Kartaltepe Mah. Atakan Sok. No: 3/ASefaköy, Küçükçekmece – İSTANBUL (6977922)
7. Aircraft Accident Crimea Rescue and Fire Fighting Book.2021 Telli Ali Fatih Çivici, Ali Kutlu Yayınevi Basım Yayım Dağıtım Ltd. Şti. Kartaltepe Mah. Atakan Sok. No: 3/ASefaköy, Küçükçekmece – İSTANBUL(6920291)
8. Forest Book 2020.ALITELLİ Ali Kutlu Yayınevi Basım Yayım Dağıtım Ltd. Şti. Kartaltepe Mah. Atakan Sok. No: 3/ASefaköy, Küçükçekmece – İSTANBUL (6801670)
9. Rope Access And Rescue Techniques Book.2019 Telli Ali,Buldu Bülent, Savaş Kitap Basım Yayım Dağ. TİC. LTD. ŞTİ. Ostim Mahallesi 1208. Cadde No. 9 Yenimahalle / Ostim – Ankara Telefon**:** 0312 434 35 97 - 0312 432 44 29 Faks: 0312 432 44 28 - Şube: AÜHF Öğrenci Girişi Cebeci / ANKARA(5620032)
10. Fire Criminology Information Book.2019 Telli Ali, Kavcin Azmet Başar , Seçkin Yayıncılık Sanayi ve Ticaret A.Ş**.** Eskişehir Yolu, Mustafa Kemal Mah. 2158. Sokak No:13 Çankaya/ANKARATel: 0 312 435 30 30 Faks: 0 312 435 24 72 E-posta: seckin@seckin.com.tr (5126852)
11. Forest Fires Book.2018 Telli Ali,Kavcin Azmet Başar,Kesler Eren. Ali Kutlu Yayınevi Basım Yayım Dağıtım Ltd. Şti. Kartaltepe Mah. Atakan Sok. No: 3/ASefaköy, Küçükçekmece – İSTANBUL (4181014)

NEW SEISMO-SAFE SYSTEM OF PREFABRICATED INDUSTRIAL HALLS WITH TEST-PROVED MODELS OF CRITICAL CONNECTIONS

Jelena Ristic[1], Danilo Ristic[2], Nenad Golubovic[3], Lela Mitic[4], Denis Milenovic[5]

[1] Asst. Prof. PhD., International Balkan University (IBU), Faculty of Engineering, Department of Civil Engineering, Skopje, North Macedonia, risticjelenaibu@gmail.com
[2] Full Prof. PhD., SS Cyril and Methodius University in Skopje, Institute of Earthquake Engineering and Engineering Seismology (IZIIS), Skopje, North Macedonia danilo.ristic@gmail.com
[3,4,5] Grad. Civ. Eng., PUT INZENEERING, Knjazevacka, Nish, Serbia, golubovicn@putinzenjering.com

Abstract. *Heavy damages and total collapses of prefabricated industrial halls was observed in past earthquakes widely in the world. Regarding the present need, conducted was specific large-scale research project leaded by the first author, "Development of optimal prefabricated system of industrial halls applicable in seismic zones with higher intensity, including seismic intensity IX", supported by well-known Serbian PUT INZENEERING construction company. Based on conducted intensive testing in Skopje RESIN laboratory of constructed large-scale prototype models of critical connections, the advanced novel seismically resistant (NSR) prefabricated system of industrial halls has been successfully developed. Improved seismic safety of the system was achieved by combined application of new concepts of critical connections along with added new integrating segments of the global structural units.*

Keywords: *Industrial hall; prefabricated structure; nonlinear response; seismic safety; critical connections.*

1. INTRODUCTION

Industrial facilities representing large industrial halls are, in recent years, rapidly constructed in the region of South East Europe (SEE) and wider, applying various precast RC systems. High seismic risk of precast industrial halls, including heavy damages and total collapses, was commonly observed in past earthquakes widely in the world, [2-4], [6], [8-11]. It clearly points out the urgent need to seriously treat this problem in regard of providing essential structural safety, sustainable economic and social development and general seismic security in seismically active regions. The created specific seismic risk of this type has not been well quantified to this date and sound seismic risk mitigation concepts are not available. Considering the above stated, led by the first author, conducted was extensive experimental and theoretical research in the frame of initiated large-scale research project "Development of optimal prefabricated system of industrial halls applicable in seismic zones with higher intensity, including seismic intensity IX", supported by known Serbian PUT INZENJERING construction company, [13-18]. The advanced novel seismically resistant (NSR) prefabricated system of industrial halls has been successfully developed based on combined intensive testing of constructed large-scale prototype models of critical connections in Skopje RESIN laboratory and conducted specific nonlinear seismic behavior studies of integral structures, [1], [7], [12]. The proposed seismically resistant prefabricated system of industrial halls was developed through application of advanced concepts for detailing of critical connections and incorporated steel truss segments as integrating systems of the global structural units, [19], [20]. Beside obtained original experimental results from conducted experimental tests, in the paper are also presented some fundamental innovative end-products which are highly important for the creation of the presently proposed novel seismically resistant (NSR) prefabricated system of industrial halls, including: (D1) Basic design concept of structurally sound connection of precast RC column with precast RC footing and representative experimentaly proved nonlinear behaviour model; (D2) Experimentally proved design concept of solid prefabricated joint between RC column and RC corbel (short cantilever) and corbel's safety margins; (D3) Experimentally proved design concept and nonlinear behavior modeling approach of both, original and improved original connection between precast longitudinal RC beam and RC column; (D4) Experimentally proved design concept and nonlinear behavior modeling approach of both, original and improved original connection between precast roof RC beam and RC column; (D5) Advanced experimentally proved nonlinear analysis procedure providing its wide application for design of novel seismically resistant prefabricated system (*NSR-prefabricated system*) of industrial halls in seismic zones characterized with expected significant and/ orvery high seismic intensity.

2. PROTOTYPE COLUMN-FOOTING CONNECTION TEST: MODELM1

Providing safety and controlled behaviour of connection between precast RC column and precast RC footing is very important condition for assuring seismic stability of the integral precast structural system. To get full evidence in real nonlinear behaviour characteristics of this critical connection type, performed was detailed test model design, common production and laboratory testing up-to failure of representative prototype model–M1 in the scale M=1:2. Experimental test was realized on existing laboratory testing frame under simulated constant vertical load and horizontal cyclic displacement with increasing amplitude up-to deep nonlinearity. Model test set-up is shown in Figure 1. Experimental model–M1 is composed of precast RC footing and precast RC column with cross-section dimensions 30x30cm and its total length of L=165.0cm. Column length l_1=50cm was installed in footing box and the remaining column`s length of l_2=115cm was used for application of simultaneous vertical and horizontal cyclic load. Longitudinal reinforcement consisted of 12ϕ10mm steel bars and special confining ties of ϕ= 6mm spaced at distance of e=10cm. Footing RC base plate dimensions are d=25 cm and a/b=120x100cm, reinforced with steel bars ± 9ϕ12mm and ± 7ϕ12mm in both sides directions, was fixed to the frame base with 6 bolts with diameter of ϕ32mm.
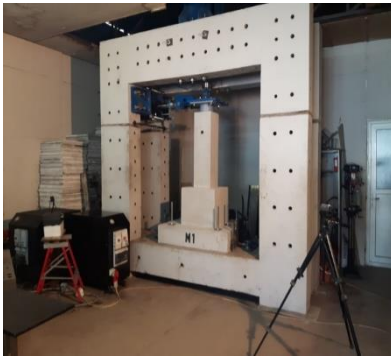
Fig. 1. Set-up of 1/2 scaled model M1 in laboratory testing frame

Fig. 2. Initiated damage at PC column

Fig. 3. Heavy damage at PC column (footing safe)
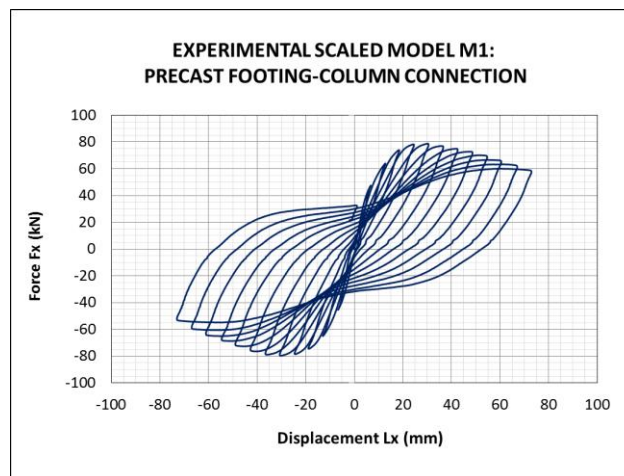
Fig. 1a. Force-displacement hysteretic response recorded from the test of prototype model M1

The RC footing box is with outer dimensions of 60x60cm and bottom inner dimensions of 35x35cm were used to fix RC column applying standard putinzenjering technology. The four side-walls of RC box were reinforced at both faces using 16+16=32ϕ8 steel bars as vertical reinforcement and the horizontal reinforcement existed of 6ϕ8 and 6ϕ8 steel bars at outer and inner wall faces, respectively. The recorded hysteretic curve from the performed experimental test, Figure 1a, showed very stable nonlinear behaviour resulting from induced plastic hinge only in column's critical

section. RC footing box was fully safe and damage was observed only in critical section zone of RC column, Figure 2 and Figure 3. Maximum horizontal restoring force of $F_{max}=\pm80.0kN$ was recorded for displacement of $d=\pm25mm$. However, for induced maximum displacement of $D_{max}=\pm74.0mm$, the recorded horizontal force amounted to $F=\pm55.0kN$. So, obtained is small reduction of only 25.7% along with the recorded very stable hysteretic relation without any visible cracks in the foundation box. The test results have clearly shown perfect and controlled nonlinear behaviour of the assembled precast column-footing connection, confirming full validity of the developed production technology.

3. TESTING OF PROTOTYPE BEAM SUPPORT ON RC CORBEL: MODELM2

In the cases of construction of two-story structures, longitudinal precast RC beams are supported on RC corbel (short cantilever) constructed during production of precast RC column.

Fig. 4. Set-up of 1/2 scaled prototype model M2 in laboratory testing frame

Fig. 5. Reinforcement ofcolumn with corbel

Fig. 6. Loading of RC corbel using rubber pad

Safety state of short cantilever under maximum design load was, in the frame of the present project, experimentally tested using specifically designed experimental model–M2. In Figure 4 shown is test set-up of experimental model-M2 in the laboratory testing frame along with the applied vertical loading system composed of hydraulic actuator. Model base fixation support was constructed in the form of RC footing with dimensions 60x71cm and thickness of t=30cm. The footing was reinforced in both directions and equal in bottom and top zone with $\pm6\phi12mm$ and $\pm8\phi12mm$ steel bars, respectively. For fixing the model footing to the frame base, fours steel bolts of $\phi32mm$ were used. Above the footing constructed was segment of precast column with corbel. Considered cross section of the column was 30x30cm and its total length above footing was L=135cm, being 30cm below corbel, then corbel height 30cm and 75cm above the corbel. Longitudinal reinforcement of the column consisted of $12\phi10mm$ longitudinal steel bars and steel ties$\phi6mm$ installed at distance of 10cm, Figure 5. Corbel contact face with column was 30cmx30cm, its span was L=20cm and free face was reduced to 30x20cm adapting linear variation of corbel height. Reinforcement of corbel consisted of$4\phi10mm$ bars in upper and $4\phi10mm$ bars in lower zone, respectively. Confinement was assured using specially formed ties$\phi6mm$ installed in two directions. To increase safety of corbel added are inclined three steel anchors $\phi6mm$ in the shape of letter U. Corbel loading was provided with steel plate being above neoprene layer with d=10mm and by vertical steel component with hollow section 180x260x10mm, directed vertically by two steel belts with cross section 100x20mm, Figure 6. During experimental test, even under maximum vertical load of N=300.0kN, the precast model corbel showed perfect stability, pure linear behaviour without any visible cracks. Based on conducted experimental test, it was concluded that the developed precast corbel construction method provides reliable and safe supporting system of precast RC longitudinal beams under respective design loads.

4. PC L-BEAM WITH COLUMN CONNECTION TEST: MODELSM3-A& M3-B

Controlled safety level of the adopted connection between precast RC column and RC longitudinal beam, which is supported by RC corbel produced during construction of prefabricated RC column, is highly important connection property providing conditions to efficiently prevent severe damages during seismic loading of related structural segments. Beside provided seismic safety of prefabricated RC column and prefabricated longitudinal RC beam, as

individual structural members, their connection should also sustain required safety level for induced real seismic action under strong future earthquakes. To experimentally confirm actual nonlinear behaviour characteristics of this important connection and to provide valid design parameters assuring required and controlled seismic safety, two developed longitudinal beam-column connection options have been experimentally tested using constructed scaled (1:2) experimental models. The first tested model M3-A represent commonly used original connection (item 4.1), while the second model M3-B is recently developed and proposed, representing improved original connection option (item 4.2).

4.1. Testing of original connection of PC longitudinal beam & column: Model M3-A

Standard or original experimental model M3-A of connection between longitudinal precast beam and column was designed to include segment of precast column with corbel, segment of precast longitudinal beam and constructed connection segment applying original connection system. The column segment with corbel positioned horizontally, was used for model fixing to the base of laboratory test frame with eight bolts d=32mm, installed in constructed column supporting RC footing placed under the column segment. Footing was constructed with dimensions a/b=140x60cm and thickness t=20cm. Reinforcement of column with section 30x30 cm consisted of $12\phi10mm$ longitudinal bars and ties of $\phi6mm$ spaced at 10cm distance. Column supporting RC footing was reinforced in both faces with longitudinal reinforcement of $6\phi12mm$, respectively and ties of $\phi6mm$ spaced at distance of e=10cm. Corbel dimensions and reinforcement arrangement were adapted based on standardized method described before (item 3). Longitudinal PC beam segment with cross section in the form of inverted T was reinforced with standard longitudinal reinforcement and ties. Dimensions of base wider cross-section part were b_1/h_1=30x20cm, for vertical part b2/h2=15x20cm, resulting in total section height $h=h_1+h_2$=40cm.Standard connection system existed of two pin anchors $\phi12mm$ and l=350mm installed in the existing holes $\phi24mm$ made along the total precast beam height of 40cm. Two pin anchors were additionally fixed by inserted standard connecting emulsion. The head of precast longitudinal beam was strengthened with U shaped horizontal anchoring ties. Three anchoring ties $\phi8mm$ were applied in vertical section part having b_2=15cm and three anchoring ties $\phi8mm$ were applied in lower wider section segment having b_1=30cm. The test model M3-A set-up in laboratory testing frame is shown in Figure 7, along with vertical loading system with hydraulic actuator.
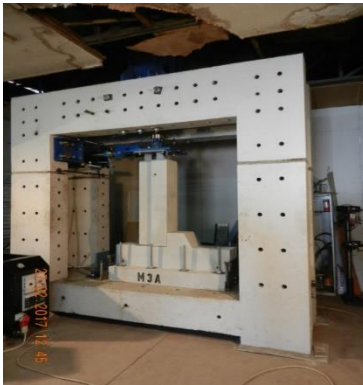
Fig. 7. Set-up of 1/2 scaled prototype model M3-A

Fig. 8. Original connection PC column and L-beam

Fig. 9. Final failure state of original connection M3-A

Table 1. Experimentally defined parameters representing nonlinear behavior of the tested original connection of prefabricated RC longitudinal beam with RC column: Model M3-A

Original M3-A connection type: L beam-column				
No. Scaled-model/full-scale	DY(m)	FY(kN)	DU(m)	FU(kN)
1 Tested scaled modelM3-A	0.0155	62.00	0.0540	100.00
2 Full-scale connection M3-A	0.0310	248.00	0.1080	400.00

Applying tension force on the vertical model segment representing longitudinal precast beam, nonlinear behaviour characteristics of original connection of precast L-beam with column have been defined and presented in Tab.1, for the tested scaled model and for full-scale connections converted values. The obtained experimentally proved bilinear model parameters represent highly valuable representative nonlinear modelling data of the original connection. The presented data can be used in the process of detailed seismic behaviour modelling and seismic response study of the integral precast structural system. The performed experimental test of prototype model connection M3-A has clearly shown all its specific behaviour phases including initial linear behaviour, crack and damage propagation and finally total failure, Fig. 8 and Fig. 9.

4.2. Test of improved original connection of PC L-beam with column: Model M3-B

To investigate possibility of upgrading of standard or original connection system M3-A, constructed was and experimentally tested experimental model M3-B, representing improved original connection system of PC longitudinal beam with column. The model components, including RC fixation footing, RC column with corbel and vertical segment representing PC longitudinal beam were constructed with the same dimensions and the same reinforcement.

The improved original connection system–2 represents structural modification of the original connection system-1 in the following two parts: (1) The basic pin anchors were produced applying $2\phi16$mm steel bars (instead of $2\phi12$mm steel bars) and (2) The three U shaped horizontal anchors in the vertical section part and three U shaped horizontal anchors in the lower wider section part were applied with larger diameter of $\phi16$mm, instead of $\phi12$mm used in the case of model M3-A.

Fig. 10. Set-up of 1/2 scaled model M3-B in referent testing frame

Fig. 11. Improved M3-B connection: C & L-beam

Fig, 12. Damage of M3-B improved connection

Table 2. Experimentally defined nonlinear behavior parameters of the tested improved original connection of prefabricated RC longitudinal beam with RC column: Model M3-B

Improved original M3-B connection type: L beam-column				
No. Scaled-model/full-scale	DY(m)	FY(kN)	DU(m)	FU(kN)
1 Tested scaled model M3-B	0.0030	44.00	0.0480	120.00
2 Full-scale connection M3-B	0.0060	176.00	0.0960	480.00

Experimental model set-up as well as loading system of experimental model M3-B are considered the same, Figure 10. From conducted experimental test defined were actual nonlinear behaviour characteristics of the proposed improved original connection system M3-B, including linear stage, damage propagation stage and total failure, Figure 11 and Figure 12. Nonlinear behaviour characteristics of the tested improved original connection M3-B of PC beam-PC column, respectively for scaled model and full-scale connection are presented in Table 2. The presented parameters of bilinear models for M3-A & M3-B show some differences. For M3-B recorded is enlargement of failure force for 20% because FU=100N and FU=120kN, respectively for original and improved connection, Table 1&Table 2.

5. PC ROOF-BEAM & COLUMN CONNECTION TEST: MODELSM4-A&M4-B

Without any exception, connection between precast RC roof beam and precast RC concrete column exists in every PUTINZENGERING industrial hall structure. It is located in the highest structural zone and commonly is exposed to not very well-defined forces under strong earthquake excitations. The safety of the implemented connection system between precast heavy roof beam and column is one the basic requirements to assure seismic resistance of the integral structural system. To obtain full evidence in real nonlinear behaviour characteristics of this important connection system performed was extensive experimental laboratory study including experimental tests of constructed related large-scale testing models with two options. Experimental test model M4-A, representing the developed original connection system and experimental test model M4-B, representing improved original connection system between precast roof beam and precast column. The experimental test models have been originally assembled using specific parts of structural components that will provide its successful testing on existing laboratory test frame. Significant structural part of the column, with cross-section 30x30cm, was considered as horizontal and its top part (left in Figure 13) with height of hc=44cm was constructed in the form of twin RC walls. Both end column walls with thickness of $t_1=t_2=9$cm were constructed with free distance of d=12cm between them to provide resting of end vertical part of T-type roof beam. Bellow the precast column, constructed was RC footing part with thickness t=20cm and with dimensions in plane 150x60cm, providing model fixation to the base of the testing frame with eight bolts with diameter of 32mm.The end part of the typical T-type roof beam was considered vertical. Its lower part, resting on the PC column, was used to apply related connection system, while the upper part of the roof beam was appropriately equipped with connecting steel device used for application of prescribed tension loading. Two types of roof beam-column connection systems have been tested. The first, representing original connection system was tested using model M4-A (item 5.1), while experimental model M4-B was constructed and used to test connection system-2, representing improved original connection system between precast roof beam and column (item 5.2).

5.1. Testing of original connection of PC roof beam with column: Model M4-A

Experimental test model M4-A was constructed considering reinforcement of the footing part and the column part the same as in the case of tested models M3-A and M3-B. Similarly, the implemented T-type roof beam is constructed with common reinforcement in its regular part out of the zone of connection. The applied connection in experimental model M4-A, representing original connection system-1 was developed based on application of the following four specific structural detailing measures as follows: (1) At both side walls of RC column installed were special pin anchors with diameter ϕ12mm entering in the hole at both sides of precast roof T-beam. Both anchors were properly fixed by injection of connecting emulsion; (2) To provide safe transmit of load from both applied pin anchors, adopted were regular (original) arrangements of additional reinforcement at both upper sides of roof beam and at both RC walls of column; (3) To increase connection safety, adopted was central bolt of ϕ15mm through column side walls and vertical part of roof T-beam and (4) All connection contacts are finalized with commonly applied standard filling emulsion. The test set-up of experimental model M4-A is shown in Figure 13. The experimental test was completed with gradual application of increased upward vertical force up-to connection failure. Actual nonlinear characteristics of the original roof beam-column connection M4-A have been very successfully defined along with damage propagation for different displacement stages, Figure 14 and 15. The representative bilinear model properties of the tested scaled model M4-A and for full-scale connection are presented in Table 3. The presented experimentally confirmed nonlinear model properties of original connection M4-A between precast roof beam and column can be successfully applied in the process of analytical model formulation of the integral precast structural system.

Fig. 13. Set-up of 1/2 scaled prototype model M4-A

Fig. 14. Original connection: PC column-roof beam-M4-A

Fig. 15. Final failure state of original connection M4-A

Table 3. Experimentally defined parameters representing nonlinear behavior of the tested original connection of prefabricated RC roof beam with RC column: Model M4-A

Original M4-A connection type: roof beam-column					
No.	Scaled-model/full-scale	DY(m)	FY(kN)	DU(m)	FU(kN)
1	Tested scaled model M4-A	0.0020	60.00	0.0380	108.00
2	Full-scale connection M4-A	0.0040	240.00	0.0760	432.00

5.2. Testing of improved connection of PC roof beam & column: Model M4-B

The experimental test model M4-B, representing the improved original connection of precast roof beam and column was constructed applying the same model components as in the case of experimental model M4-A. However, to investigate possible upgrading level of connection system-1, applied is modified, i.e. improved connection system-2 which is characterized with the following structural measures: (1) Increased is the diameter of special pin anchors, in this case to d=16mm. They were located in the same positions at both RC side walls of the column. The anchors were fixed to the roof T-beam applying the same connecting concept; (2) In this case, to provide safer load transition from both stronger pin anchors, adopted was improved original arrangement of additional confining and anchoring reinforcement at both upper sides of roof beam and at both side RC walls of the column; (3) In this case adopted was central bolt with d=18mm passing through the same elements and spaced on the same location; and (4) The connection contact faces were finalized applying the same method as in the case of experimental model M4-A.

Experimental model set-up of the tested connection model M4-B is presented in Figure 16. Details of crack propagation during the model testing are shown in Figure 17 and Figure 18. From experimental test of improved original connection model M4-B, representing connection between roof beam and column, defined were related nonlinear characteristics of analytical bilinear model for both, scaled connection model and full-scale connection, Table 4.

Fig. 16. Set-up of 1/2 scaled model M4-B in testing frame

Fig. 17. Improved column & roof beam connection

Fig. 18. Failure of improved original connection M4-B

Table 4. Experimentally defined parameters representing nonlinear behavior of the tested improved original connection of prefabricated RCroof beam with RC column: Model M4-B

Improved original M4-B connection type: roof beam-column					
No.	Scaled-model/full-scale	DY(m)	FY(kN)	DU(m)	FU(kN)
1	Tested scaled model M4-B	0.0030	70.00	0.0600	190.00
2	Full-scale connection M4-B	0.0060	280.00	0.1200	760.00

Comparing ultimate force obtained from the tested original connection model M4-A ranging to FU=108kN, with ultimate force recorded for improved original model connection M4-B ranging to FU=190kN, significant increase of ultimate strength of 75.9% has been achieved. The obtained original experimental data represents highly important experimental evidence providing proved conditions for detailed modelling and seismic safety analysis of the integral systems of precast structures having various geometrical and global shape properties.

6. MODELING OF NSR SYSTEM WITH TESTED CONNECTIONS

Using experimentally proved nonlinear behaviour characteristics of the implemented structural connections, in SAP2000 formulated was nonlinear analytical model of integral full-scale prototype precast industrial hall structure and used to study its seismic response performances under the effect of strong earthquakes, Figure 21. The structure represents precast frame system, formed by installed seven frames parallel to x axis, integrating in total 27 columns supported by 27 individual precast foundations with variable dimensions 400x400cm, 300x300cm and 250x250cm, depending on actual vertical load and column cross-sections. In x and y direction, the structure dimensions in plan are L_x=44.0m and L_y=63.75m. The columns are designed with three different cross-sections, first 80x80cm (cast with concrete C40), second 70x70cm (C50) and last 60x60cm (C50), reinforced respectively with longitudinal bars 20ϕ28mm, 16ϕ25mm and 8ϕ25mm and with tiesϕ6/15cm. The height of central and side columns are, H_c=14.2m and H_s=11.94m, respectively.
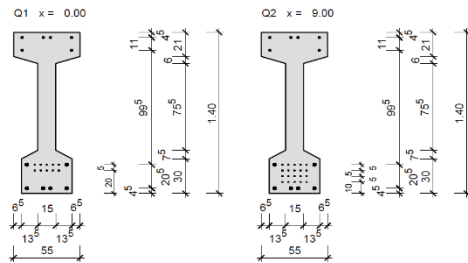
Fig. 19. Main prestressed beam I140 used in prefabricated NSR structure
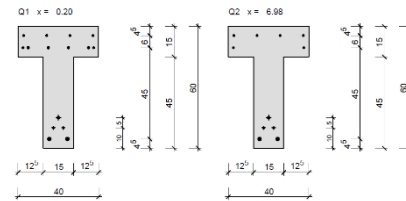
Fig. 20. Longitudinal prestressed beam T60 used in prefabricated NSR structure

The roof structure is formed with precast roof I-beams with h=140cm and span L=22m, Fig. 19, precast T-beams with h=90cm and L=11.0m; longitudinal precast T-beams with h=60cm and L=15.0m, Fig. 19 and longitudinal precast T-beams with h=45.0cm and L=8.75m. Steel trusses integrating the structure consist of hollow rectangular braces 160x160x4 mm, 100x100x4mm and 80x80x4mm and brace filling rebar d=25mm. Nonlinear behaviour of columns above foundations were simulated by hysteretic Takeda model based on previously performed detailed analysis of moment-curvature relations for all respective sections of columns. Nonlinear behaviour of the existing connections of precast roof-beams with precast columns and longitudinal precast beams with precast columns were realistically modelled based on experimentally proved nonlinear model parameters from conducted experimental laboratory tests, Figure 22 and Figure 23.
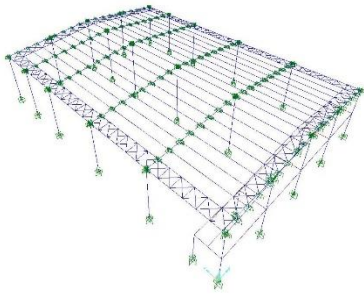
Fig. 21. Nonlinear 3D model of full scale prefabricated NSR structure
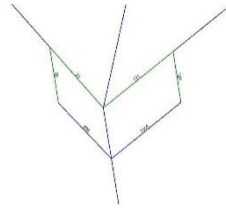
Fig. 22. Connection model above corner column
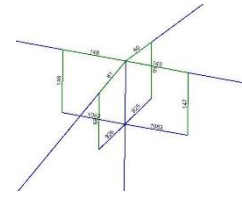
Fig. 23. Connect. model above central column

From the analysis of the dynamic characteristics for the initial state of the structure defined were the following vibration periods of the first three modes: $T_1=1.526s$, $T_2=1.445s$ and $T_3=1.305$ s, dominantly exposed in x-direction, y-direction and in torsion mode, respectively. Seismic response of the integral structure has been analysed for earthquake action simultaneously in both x and y direction, considering seismic ground motion to act under the angle of 45º in respect to the global x-axis. In this paper included are results obtained for simulated Ulcinj-Albatros earthquake record scaled to very high intensity represented by peak ground acceleration PGA=0.60g.
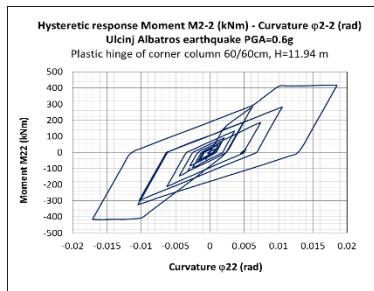
Fig. 24. Hysteretic response M22-ϕ of corner column under strong seismic load: PGA=0.6g
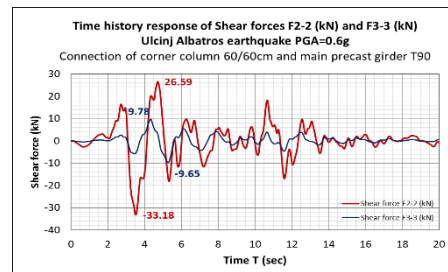
Fig. 25. Time-history response of connection forces above corner column under strong seismic load
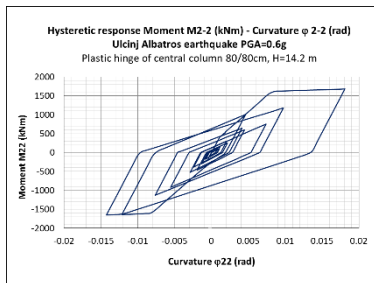
Fig. 26. Hysteretic response M22-ϕ of central column under strong seismic load: PGA=0.6g
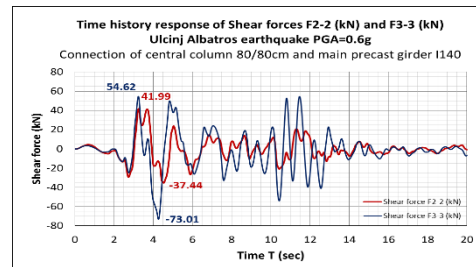
Fig. 27. Time-history response of connection forces above central column under strong seismic load

Structural response of the integral structure was generally characterized by the following important observations: (1) During the lower intensity level, specifically during the first 2-3 sec, structural response was completely linear and all critical column sections and all modelled connections were not cracked; (2) During the increased earthquake intensity, time segment t=3-6sec, critical sections of the columns in both directions were exposed to intensive nonlinear response represented by opened hysteretic curves, Figure 24, Figure 26, Figure 28 and Figure 29.
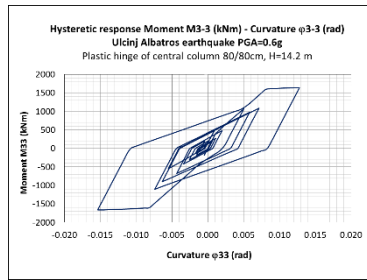
Fig. 28. Hysteretic response M33-ϕ of central column under strong seismic load: PGA=0.6g
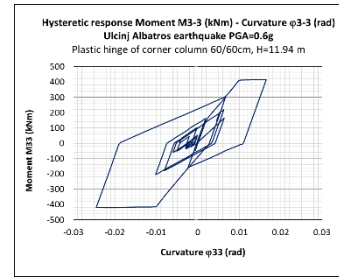
Fig. 29. Hysteretic response M33-ϕ of corner column under strong seismic load: PGA=0.6g

During this time segment, in all horizontal connections recorded was increased level of induced forces, Figure 25 and Figure 27; (3) The increased level of forces in these connections are not higher than yield forces and the connections are remaining safe and undisturbed and (4) If input earthquake intensity will be further increased, the failure of the structure is expected to be produced due to failure of the columns; (5) Column`s controlled failure is in this case advanced strategy and can be avoided during the advanced design process and (6) During the third time segment, t=6-20s, the structure was vibrating around new very little changed deformed state, but the system remained integrally safe. The observed global seismic response of NSR prefabricated structure, characterized by controlled and favorable behavior, actually represents advanced strategy to minimize seismic risk and to assure full seismic stability of this specific and other important structural types.

7. CONCLUSIONS

From the conducted extensive experimental testing of various developed and implemented connection types of the novel seismically resistant NSR PUTINZENJERING prefabricated system the following conclusions are summarized: (1) Prefabricated standard footing showed full safety for seismic loads in the case of installation of columns with standard respective cross sections and reinforcement; (2) Prefabricated RC columns showed stable nonlinear hysteretic behavior under cyclic loads along with expressed ductility for the case of implemented ties spaced in prescribed small distances; (3) The implemented RC corbels supporting L-beams possess high safety for the prescribed design loads; (4) From experimental tests confirmed was that nonlinear behavior characteristics of the developed L beam-column connection types and roof beam–column connection types possess stable and favorable behavior properties with opened possibility for their application in seismic regions and (5) The proposed nonlinear analytical model parameters of connections represent highly valuable modeling data which can be successfully considered during the final seismic design process of NSR PUTINZENJERING prefabricated structures in seismic regions. In addition, from conducted nonlinear seismic response analysis of the integral NSR prototype structure, the following main conclusions are summarized: (1) Novel siesmo-resistant NSR PUTINZENJERING prefabricated system can be successfully applied in seismic zones with high seismic intensity based on application of the developed design principles; (2) Nonlinear response of the integral structure should be generally controlled by hysteretic ductile behavior of prefabricated columns; (3) For the case of design earthquake, the behavior of structural connections should be basically linear while for the case of maximum expected earthquake intensity, the behavior of structural connections may be in controlled nonlinear range. To efficiently define and satisfy both design stages, potential use of advanced structural analysis procedures during the design process is recommended.

REFERENCES

1. Ristic D., 1988, *Nonlinear Behavior and Stress-Strain Based Modeling of Reinforced Concrete Structures Under Earthquake Induced Bending and Varying Axial Loads, (Doctoral Dissertation)*, School of Civil Engineering, Kyoto University, Kyoto, Japan.
2. EERI, 1994, Northridge Earthquake January 17, 1994, *EERI Preliminary Reconnaissance Report*, Earthquake Engineering Research Institute, 104pp, 1994.
3. Muguruma H., Nishiyama M., Watanabe F., 1995, *Lessons learned from Kobe earthquake, A Japanese perspective*, PCI Journal, V40, N4, July/August, pp.28-42, 1995.
4. EERI, 2000, Kocaeli, Turkey, Earthquake of August 17, 1999, *EERI Reconnaissance Report*, Earthquake Spectra, Supplement to Vol. 16. 2000.
5. Wilson L. Edward, 2002, *Three-Dimensional Static and Dynamic Analysis of Structures: A Physical Approach With Emphasis on Earthquake Eng.,* Berkeley, California: Third Ed., 2002.
6. Posada M., Wood S.L., 2002, *Seismic performance of precast industrial buildings in Turkey.* Proc. of the 7th U.S. National Conference on Earthquake Engineering, July 21-25, 2002, Boston, MA, USA, EERI publications.
7. Doneux C., Hausoul N., Plumier A., 2006, Deliverable 55 "Analysis of 3 precast RC structures with dissipative connections", LESSLOSS Sub-Project 7 – Techniques and methods for vulnerability reduction.
8. Myiamoto, 2009, *2009 M6.3 L'Aquila, Italy, Earthquake Investigation Report*, Global Risk Myiamoto, 2009.
9. Zhaoa B., Taucera F., Rossetto T., 2009, *Field investigation on the performance of building structures during the 12 May 2008 Wenchuan earthquake in China,* Engineering Structures, 31 (2009) 1707–1723, 2009.
10. Senel S.M., and Kayhan A.H. 2010, *Fragility based damage assessment in existing precast industrial buildings: A case study for Turkey,* Structural Engineering and Mechanics, Vol. 34, No. 1 (2010) 39-60, 2010.
11. Decanini L. D., Liberatore L., Sorrentino L., 2012, *Preliminary Report on the 2012, May 20 Emilia Earthquake,* May 2012, v.1, Univ. "La Sapienza" of Rome, Department of Structural Engineering and Geotechnics, Italy, 2012.
12. Ristik J., 2016, *Modern technology for seismic protection of bridges with application of new seismic response modification system,* Doctoral dissertation, Institute of earthquake engineering and engineering seismology (IZIIS), University Ss. Cyril and Methodius, Skopje, Macedonia, 2016.
13. Ristik J., Pavlov S., Pavlov P., Ristic D., 2017, *Laboratory Testing of Constructed Prototype Models of Typical Connections Used in Prefabricated RC Construction System of Industrial Halls Implemented by PUT Inzenering, Serbia: Experimental Laboratory Testing of Prototype Model-M1 Representing Connection Between Prefabricated Column and Prefabricated Footing,* RESIN Lab. of Industrial Sciences and Technology, Report: RESIN-011-2017.
14. Ristik J., Pavlov S., Pavlov P., Ristic D., 2017, *Laboratory Testing of Constructed Prototype Models of Typical Connections Used in Prefabricated RC Construction System of Industrial Halls Implemented by PUT Inzenering, Serbia: Experimental Laboratory Testing of Prototype Model-M2 Representing Beam Support Fromed as RC Column-Short Cantilever (Corbel),* RESIN Laboratory of Industrial Sciences and Technology, Report: RESIN-012-2017.
15. Ristik J., Pavlov S., Pavlov P., Ristic D., 2017, *Laboratory Testing of Constructed Prototype Models of Typical Connections Used in Prefabricated RC Construction System of Industrial Halls Implemented by PUT Inzenering, Serbia: Experimental Laboratory Testing of Prototype Model-M3a Representing Original Connection of Prefabricated Longitudinal Beam with Column,* RESIN Lab. of Industrial Sciences and Technology, Report: RESIN-013-2017.
16. Ristik J., Pavlov S., Pavlov P., Ristic D., 2017, *Laboratory Testing of Constructed Prototype Models of Typical Connections Used in Prefabricated RC Construction System of Industrial Halls Implemented by PUT Inzenering, Serbia: Experimental Laboratory Testing of Prototype Model-M3b Representing Improved Original Connection of Prefabricated Longitudinal Beam With Column,* RESIN Laboratory of Industrial Sciences and Technology, Report: RESIN-014-2017.
17. Ristik J., Pavlov S., Pavlov P., Ristic D., 2017, *Laboratory Testing of Constructed Prototype Models of Typical Connections Used in Prefabricated RC Construction System of Industrial Halls Implemented by PUT Inzenering, Serbia: Experimental Laboratory Testing of Prototype Model-M4a Representing Original Connection of Prefabricated Roof Beam With Column,* RESIN Lab. of Industrial Sciences and Technology, Report: RESIN-015-2017.
18. Ristik J., Pavlov S., Pavlov P., Ristic D., 2017, *Laboratory Testing of Constructed Prototype Models of Typical Connections Used in Prefabricated RC Construction System of Industrial Halls Implemented by PUT Inzenering, Serbia: Experimental Laboratory Testing of Prototype Model-M4b Representing Improved Original Connection of Prefabricated Roof Beam With Column,* RESIN Lab. of Industrial Sciences and Technology, Report: RESIN-016-2017.
19. Fangfang Geng, Youliang Ding, Honglei Wu, Xiaoning Cai, Yun Zhang., 2021, *Experimental investigation and seismic response behavior of a self-centering precast concrete frame with hysteretic dampers,* Engineering Structures, Volume 240, 2021,
20. Marco Breccolotti, Luca Brocchi, Annibale Luigi Materazzi, 2021, *Ductility evaluation of precast RC shear walls in Italian existing buildings,* Engineering Structures, Volume 240, 2021.

RESULTS OF COMPARISON BETWEEN DIFFERENT SORTING ALGORITHMS

Assoc. Prof. Dr. Festim Halili[1], Edlira Dika[2]

[1,2]Computer Engineering, Faculty of Engineering, International Balkan University, Macedonia

Abstract. *Analysis of algorithms is an issue that has always stimulate enormous curiosity. There are logical techniques for estimating the complexity of an algorithm. Generally, a more convenient solution is to estimate the run time analysis of the algorithm. The present piece of investigation documents the comparative analysis of five different sorting algorithms of data structures Bubble Sort, Heap Sort, Straight Insertion Sort, Shell Insertion Sort, and Quick Sort. The running time of these algorithms is calculated with the C++ language. These sorting algorithms are also compared on the basis of various parameters like complexity, method, memory, etc.*

Keywords: *sorting algorithms; sort; algorithm.*

1. INTRODUCTION

A Sorting Algorithm is used to rearrange a given array or list elements according to a comparison operator on the elements. The comparison operator is used to decide the new order of elements in the respective data structure.
In other words, sorting algorithms are ways to organize an array of items from smallest to largest. These algorithms can be used to organize messy data and make it easier to use.
Sorting properties:
  A. *Adaptive*
     A sort is adaptive if it runs faster on a partially sorted array.
  B. *Stable*
     A sort is stable if it preserves the relative order of equal keys in the database.
  C. *In Situ*
     An in situ ("in place") sort moves the items within the array itself and, thus, requires only a small O(1) amount of extra storage.
  D. *Online*
     An online sort can process its data piece-by-piece in serial fashion without having the entire array available from the beginning of the algorithm.

2. FIVE SORTING ALGORITHMS

In this paper, is discussed for five sorting algorithms:

1.   Straight Insertion Sort

2.   Shell Insertion Sort

3.   Heap Sort

4.   Quick Sort

5.   Bubble Sort

2.1 Straight Insertion Sort

Straight insertion sort is one of the most basic sorting algorithms that essentially inserts an element into the right position of an already sorted list. It is usually added at the end of a new array and moves down until it finds an element smaller than itself (the desired position). The process repeats for all the elements in the unsorted array.

Consider the array {3,1,2,5,4}, we begin at 3, and since there are no other elements in the sorted array, the sorted array becomes just {3}. Afterward, we insert 1 which is smaller than 3, so it would move in front of 3 making the array {1,3}. This same process is repeated down the line until we get the array {1,2,3,4,5}.

The advantages of this process are that it is straightforward and easy to implement. Also, it is relatively quick when there are small amounts of elements to sort. It can also turn into binary insertion which is when you compare over longer distances and narrow it down to the right spot instead of comparing against every single element before the right place. However, a straight insertion sort is usually slow whenever the list becomes large.

Main Characteristics: Insertion sort family
Straightforward and simple
Worst case = O(n^2)

Table 1. Straight Insertion Sort Complexity

Time Complexity	
Best	$O(n)$
Worst	$O(n^2)$
Average	$O(n^2)$
Space Complexity	$O(1)$
Stability	Yes

Time Complexities

- **Worst Case Complexity: $O(n^2)$**

Suppose, an array is in ascending order, and you want to sort it in descending order. In this case, worst case complexity occurs.

Each element has to be compared with each of the other elements so, for every nth element, **(n-1)** number of comparisons are made.

Thus, the total number of comparisons = **n*(n-1) ~ n^2**

To insert the last element, we need at most n-1n−1 comparisons and at most **n-1** swaps. To insert the second to last element, we need at most **n-2** comparisons and at most **n-2** swaps, and so on. The number of operations needed to perform insertion sort is therefore: **2×(1+2+⋯+n−2+n−1)**. To calculate the recurrence relation for this algorithm, we use the following summation:

$$\sum_{q=1}^{p} q = p(p+1)/2$$

It follows that,

2(n−1)(n−1+1)/2 =n(n−1)

- **Best Case Complexity: $O(n)$**

When the array is already sorted, the outer loops run for n number of times whereas the inner loop does not run at all. So, there are only n number of comparisons. Thus, complexity is linear.

- **Average Case Complexity: $O(n^2)$**

It occurs when the elements of an array are in jumbled order (neither ascending nor descending).

Space Complexity

Space complexity is **O(1)** because an extra variable **key** is used.
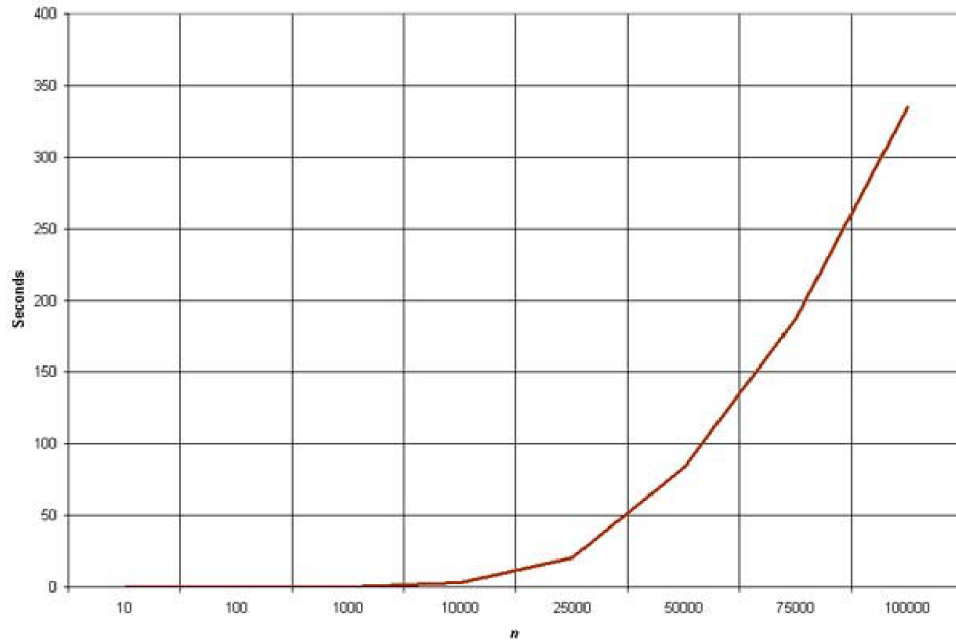
Figure 1. Insertion Sort Efficiency

The graph demonstrates the n2 complexity of the insertion sort.

The insertion sort is a good middle-of-the-road choice for sorting lists of a few thousand items or less. The algorithm is significantly simpler than the shell sort, with only a small trade-off in efficiency. At the same time, the insertion sort is over twice as fast as the bubble sort and almost 40% faster than the selection sort. The insertion sort shouldn't be used for sorting lists larger than a couple thousand items or repetitive sorting of lists larger than a couple hundred items.

```
void insertionSort()
{
int temp;
for(long i = 1; i < length; i++)
{
temp = list[i];
long j;
for(j = i-1; j >= 0 && list[j] > temp; j--)
{
list[j+1] = list[j];
}
list[j+1] = temp;
}}
```

Code one

2.2 Shell Insertion Sort

Shell sort is an insertion sort that first partially sorts its data and then finishes the sort by running an insertion sort algorithm on the entire array. It generally starts by choosing small subsets of the array and sorting those arrays. Afterward, it repeats the same process with larger subsets until it reaches a point where the subset is the array, and the entire thing becomes sorted. The advantage of doing this is that having the array almost entirely sorted helps the final insertion sort achieve or be close to its most efficient scenario.

41

Furthermore, increasing the size of the subsets is achieved through a decreasing increment term. The increment term essentially chooses every kth element to put into the subset. It starts large, leading to smaller (more spread out) groups, and it becomes smaller until it becomes 1 (all of the array).

The main advantage of this sorting algorithm is that it is more efficient than a regular insertion sort. Also, there are a variety of different algorithms that seek to optimize shell sort by changing the way the increment decreases since the only restriction is that the last term in the sequence of increments is 1. (The most popular is usually Knuth's method which uses the formula $h=((3^k)-1)/2$ giving us a sequence of intervals of 1 (k=1),4 (k=2),13 (k=3), and so on. On the other hand, shell sort is not as efficient as other sorting algorithms such as quicksort and merge sort.)

Main Characteristics:　　Sorting by insertion
　　　　　　　　　　　　Can optimize algorithm by changing increments
　　　　　　　　　　　　Using Knuth's method, the worst case is $O(n^{(3/2)})$

Table 2. Shell Sort Complexity

Time Complexity	
Best	$O(n\log n)$
Worst	$O(n^2)$
Average	$O(n\log n)$
Space Complexity	$O(1)$
Stability	No

Time Complexities

● **Worst Case Complexity: $O(n^2)$**

It is always less than or equal to $O(n^2)$

In a very worst-case scenario (which doesn't exist), each sort would be quadratic time.

comparisons ≤ n2, for 1 sort with elements 1-apart (last step)

+ 3 * (n/3)2, for 3 sorts with elements 3-apart (next-to-last step)

+ 7 * (n/7)2, for 7 sorts with elements 7-apart

+ 15 * (n/15)2, for 15 sorts with elements 15-apart

+ ...

We can see that the number of comparisons is bounded by: n2 * (1 + 1/3 + 1/7 + 1/15 + 1/31 + ...) < n2 * (1 + 1/2 + 1/4 + 1/8 + 1/16 + ...) = n2 * 2

The last step uses the sum of the geometric series.

● **Best Case Complexity: $O(n*\log n)$**

When the array is already sorted, the total number of comparisons for each interval or increment is equal to size of the array.

The best case, like insertion sort, is when the array is already sorted. Then the number of comparisons for each of the increment-based insertion sorts is the length of the array.

Therefore we can determine: comparisons =

n, for 1 sort with elements 1-apart (last step)

+ 3 * n/3, for 3 sorts with elements 3-apart (next-to-last step)

+ 7 * n/7, for 7 sorts with elements 7-apart

+ 15 * n/15, for 15 sorts with elements 15-apart

+ ...

Each term is n. The question is how many terms are there? The number of terms is the value k such that

2k - 1 < n

So k < log(n+1), meaning that the sorting time in the best case is less than n * log(n+1) = O(n*log(n)).

● **Average Case Complexity: $O(n*\log n)$**

It is around $O(n^{1.25})$.

The complexity depends on the interval chosen. The above complexities differ for different increment sequences chosen. Best increment sequence is unknown.

Space Complexity
Space complexity is **O(1).**
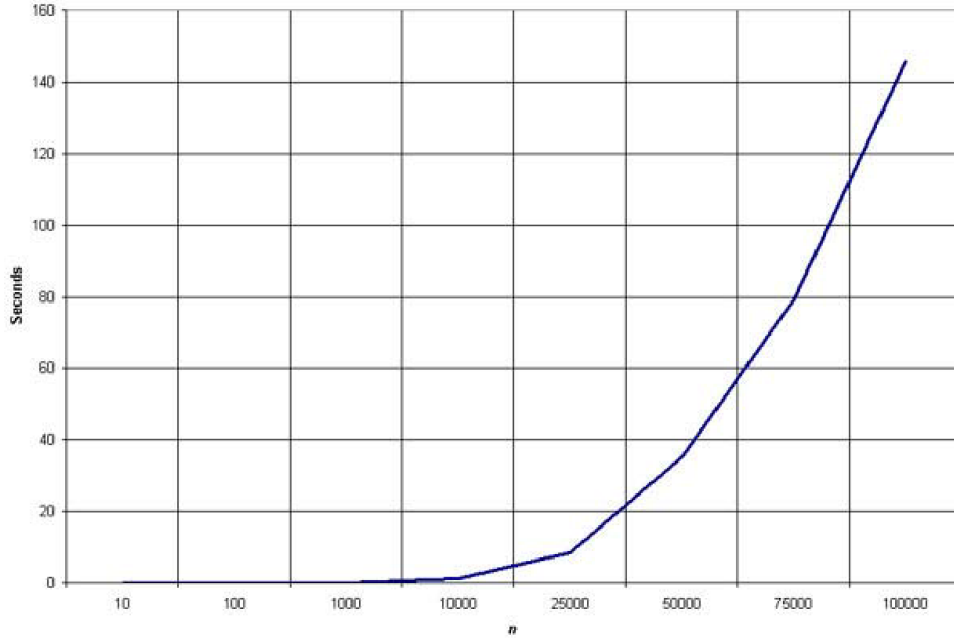
Figure 2. Shell Sort Efficiency

The shell sort is by far the fastest of the N2 class of sorting algorithms. It's more than 5 times faster than the bubble sort and a little over twice as fast as the insertion sort, its closest competitor. The shell sort is still significantly slower than the merge, heap, and quick sorts, but its relatively simple algorithm makes it a good choice for sorting lists of less than 5000 items unless speed is hyper-critical. It's also an excellent choice for repetitive sorting of smaller lists.

```
void insertionSort()
{
    int temp;
    for(long i = 1; i < length; i++)
    {
        temp = list[i];
        long j;
        for(j = i-1; j >= 0 && list[j] > temp; j--)
        {
            list[j+1] = list[j];
        }
        list[j+1] = temp;
    }
}
```

Code two

2.3 Heap Sort

Heapsort is a sorting algorithm based on the structure of a heap. The heap is a specialized data structure found in a tree or a vector. In the first stage of the algorithm, a tree is created with the values to be sorted, starting from the left, we create the root node, with the first value. Now we create a left child node and insert the next value, at this moment we evaluate if the value set to the child node is bigger than the value at the root node, if yes, we change the values. We do this to all the trees. The initial idea is that the parent nodes always have bigger values than the child nodes.

At the end of the first step, we create a vector starting with the root value and walking from left to right filling the vector.

Now we start to compare parent and child nodes values looking for the biggest value between them, and when we find it, we change places reordering the values. In the first step, we compare the root node with the last leaf in the tree. If the root node is bigger, then we change the values and continue to repeat the process until the last leaf is the larger value. When there are no more values to rearrange, we add the last leaf to the vector and restart the process. We can see this in the image below.

Main characteristics: From the family of sorting by selection
                          Comparisons in the worst-case = O(n log n)
                          Not stable

Table 3. Heap Sort Complexity

Time Complexity	
Best	O(nlog n)
Worst	O(nlog n)
Average	O(nlog n)
Space Complexity	O(1)
Stability	No

Time Complexities

Heap Sort has **O(n*log n)** time complexities for all the cases (best case, average case, and worst case).

Let us understand the reason why. The height of a complete binary tree containing n elements is **log n**.

To fully heapify an element whose subtrees are already max-heaps, we need to keep comparing the element with its left and right children and pushing it downwards until it reaches a point where both its children are smaller than it.In the worst case scenario, we will need to move an element from the root to the leaf node making a multiple of **log(n)** comparisons and swaps.

The run-time analysis of maxifying the heap depends on the number of "trickle-downs" per node being swapped. For example, if you have n = 6 total elements and are at level i = 0, you are at the level of the leaf nodes. By looking at the heap, you can see there are 3 nodes at this level i = 0. The expression used to prove this is **n/2^i+1**.

If we are at level i, we have to go a max of i levels down. This means that if we are at level 0, we go down 0 levels, which makes sense because this is the bottom-most level where all the leaf nodes are.

Similarly, at level i = 1, we "trickle down" a maximum of 1 level. At i = 2, we "trickle" a max 2 levels down. And so forth for any level i.

Space Complexity
Space complexity is **O(1).**
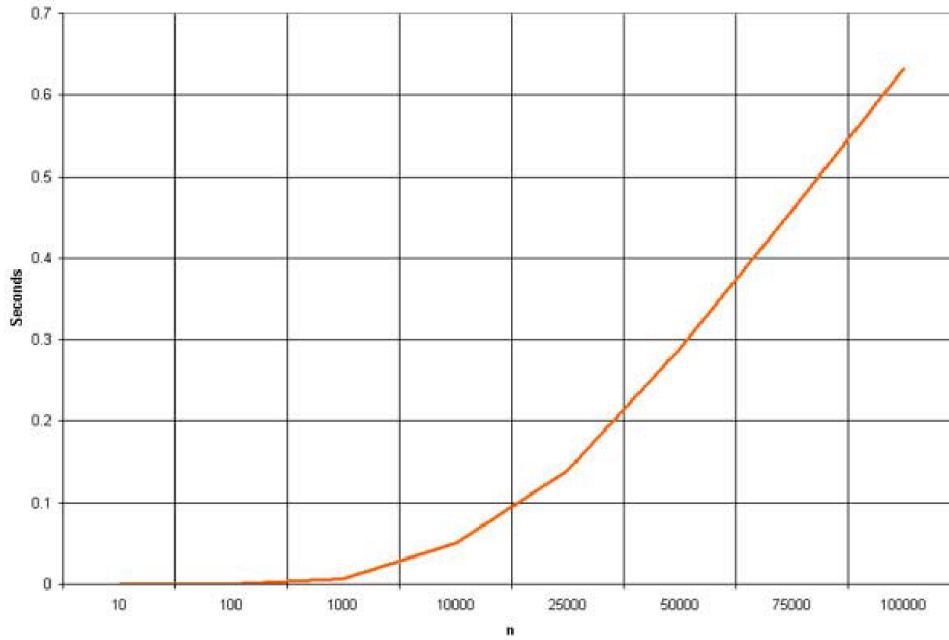
Figure 3. Heap Sort Efficiency

As mentioned above, the heap sort is slower than the merge and quick sorts but doesn't use multiple arrays or massive recursion like they do. This makes it a good choice for really large sets, but most modern computers have enough memory and processing power to handle the faster sorts unless over a million items are being sorted.

The "million item rule" is just a rule of thumb for common applications - high-end servers and workstations can probably safely handle sorting tens of millions of items with the quick or merge sorts. But if you're working on a common user-level application, there's always going to be some yahoo who tries to run it on junk machine older than the programmer who wrote it, so better safe than sorry.

```
void heapSort(long length)
{

    // Build heap (rearrange array)
    for (int i = length / 2 - 1; i >= 0; i--)
        heapify(list, length, i);

    // One by one extract an element from heap
    for (int i = length - 1; i > 0; i--) {
        // Move current root to end
        swap(list[0], list[i]);

        // call max heapify on the reduced heap
        heapify(list, i, 0);
    }
}
```

Code three

2.4 Quick Sort

Quicksort is one of the most efficient sorting algorithms, and this makes it one of the most used as well. The first thing to do is to select a pivot number, this number will separate the data, on its left are the numbers smaller than it and the greater numbers on the right. With this, we got the whole sequence partitioned. After the data is partitioned, we can assure that the partitions are oriented, we know that we have bigger values on the right and smaller values on the left. The quicksort uses this divide and conquers algorithm with recursion. So, now that we have the data divided we use recursion to call the same method and pass the left half of the data, and after the right half to keep separating and ordinating the data. At the end of the execution, we will have the data all sorted.

Main characteristics: From the family of Exchange Sort Algorithms

Divide and conquer paradigm

Worst-case complexity O(n²)

Table 4. Quick Sort Complexity

Time Complexity	
Best	$O(n\log n)$
Worst	$O(n^2)$
Average	$O(n\log n)$
Space Complexity	$O(\log n)$
Stability	No

Time Complexities

● **Worst Case Complexity [Big-O]: $O(n^2)$**

It occurs when the pivot element picked is either the greatest or the smallest element. This condition leads to the case in which the pivot element lies in an extreme end of the sorted array. One sub-array is always empty and another sub-array contains **n-1** elements. Thus, quicksort is called only on this sub-array. However, the quicksort algorithm has better performance for scattered pivots.

When quicksort always has the most unbalanced partitions possible, then the original call takes cncnc, n time for some constant ccc, the recursive call on n-1 elements takes c(n-1) time, the recursive call on n-2 elements takes c(n-2) time, and so on.

When we total up the partitioning times for each level, we get

cn+c(n−1)+c(n−2)+⋯+2c =c(n+(n−1)+(n−2)+⋯+2) =c((n+1)(n/2)−1) .

● **Best Case Complexity [Big-omega]: O(n*log n)**

It occurs when the pivot element is always the middle element or near to the middle element.

The former case occurs if the subarray has an odd number of elements and the pivot is right in the middle after partitioning, and each partition has (n-1)/2 elements. The latter case occurs if the subarray has an even number nnn of elements and one partition has n/2 elements with the other having n/2-1. In either of these cases, each partition has at most n/2 elements, and the tree of subproblem sizes looks a lot like the tree of subproblem sizes for merge sort, with the partitioning times looking like the merging times.

● **Average Case Complexity: O(n*log n)**

It occurs when the above conditions do not occur.

Space Complexity

Space complexity is **O(log n).**
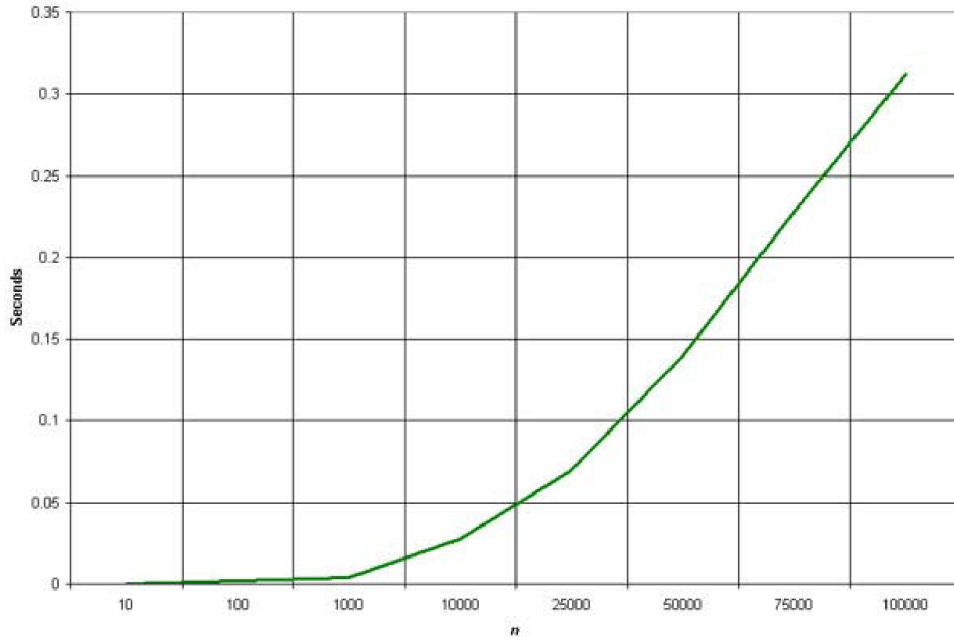
Figure 4. Quick Sort Efficiency

The quick sort is by far the fastest of the common sorting algorithms. It's possible to write a special-purpose sorting algorithm that can beat the quick sort for some data sets, but for general case sorting there isn't anything faster.

As soon as students figure this out, their immediate impulse is to use the quick sort for everything - after all, faster is better, right? It's important to resist this urge - the quick sort isn't always the best choice. As mentioned earlier, it's massively recursive (which means that for very large sorts, you can run the system out of stack space pretty easily). It's also a complex algorithm - a little too complex to make it practical for a one-time sort of 25 items, for example.

With that said, in most cases the quick sort is the best choice if speed is important (and it almost always is). Use it for repetitive sorting, sorting of medium to large lists, and as a default choice when you're not really sure which sorting algorithm to use. Ironically, the quick sort has horrible efficiency when operating on lists that are mostly sorted in either forward or reverse order - avoid it in those situations.

```
void quickSort(long left, long right)
{
    if (left < right)
    {
        long pivot = partition(left, right);
        quickSort(left, pivot-1);
        quickSort(pivot+1, right);
    }
}
```

Code four

2.5 Bubble Sort

Bubble sort compares adjacent elements of an array and organizes those elements. Its name comes from the fact that large numbers tend to "float" (bubble) to the top. It loops through an array and sees if the number at one position is greater than the number in the following position which would result in the number moving up. This cycle repeats until the algorithm has gone through the array without having to change the order. This method is advantageous

because it is simple and works very well for mostly sorted lists. As a result, programmers can quickly and easily implement this sorting algorithm. However, the tradeoff is that this is one of the slower sorting algorithms.

Main Characteristics: Exchange sorting
                           Easy to implement
                           Worst Case = O(n^2)

Table 5. Bubble Sort Complexity

Time Complexity	
Best	$O(n)$
Worst	$O(n^2)$
Average	$O(n^2)$
Space Complexity	$O(1)$
Stability	Yes

Time Complexities

- **Worst Case Complexity: $O(n^2)$**

This is the case when the array is reversely sort i.e. in descending order but we require ascending order or ascending order when descending order is needed.

The number of swaps of two elements is equal to the number of comparisons in this case as every element is out of place.

$T(N) = C(N) = S(N) = \frac{N*(N-1)}{2}$, from equation 2 and 4

Therefore, in the worst case:

Number of Comparisons: O(N^2) time

Number of swaps: O(N^2) time

- **Best Case Complexity: $O(n)$**

This case occurs when the given array is already sorted.

For the algorithm to realise this, only one walk through of the array is required during which no swaps occur (lines 9-13) and the swapped variable (false) indicates that the array is already sorted.

$T(N) = C(N) = N$

$S(N) = 0$

Therefore, in the best case:

Number of Comparisons: N = O(N) time

Number of swaps: 0 = O(1) time

- **Average Case Complexity: $O(n^2)$**

The number of comparisons is constant in Bubble Sort so in average case, there is O(N^2) comparisons. This is because irrespective of the arrangement of elements, the number of comparisons C(N) is same.

For the number of swaps, consider the following points:

If an element is in index I1 but it should be in index I2, then it will take a minimum of I2-I1 swaps to bring the element to the correct position.

An element E will be at a distance of I3 from its position in sorted array. Maximum value of I3 will be N-1 for the edge elements and it will be N/2 for the elements at the middle.

The sum of maximum difference in position across all elements will be:

(N-1) + (N-3) + (N-5) ... + 0 + ... + (N-3) + (N-1)

= N x N - 2 x (1 + 3 + 5 + ... + N/2)

= N^2 - 2 x N^2 / 4

= N^2 - N^2 / 2

= N^2 / 2

Space Complexity

- Space complexity is **O(1)** because an extra variable is used for swapping.

● In the **optimized bubble sort algorithm**, two extra variables are used. Hence, the space complexity will be **O(2)**.
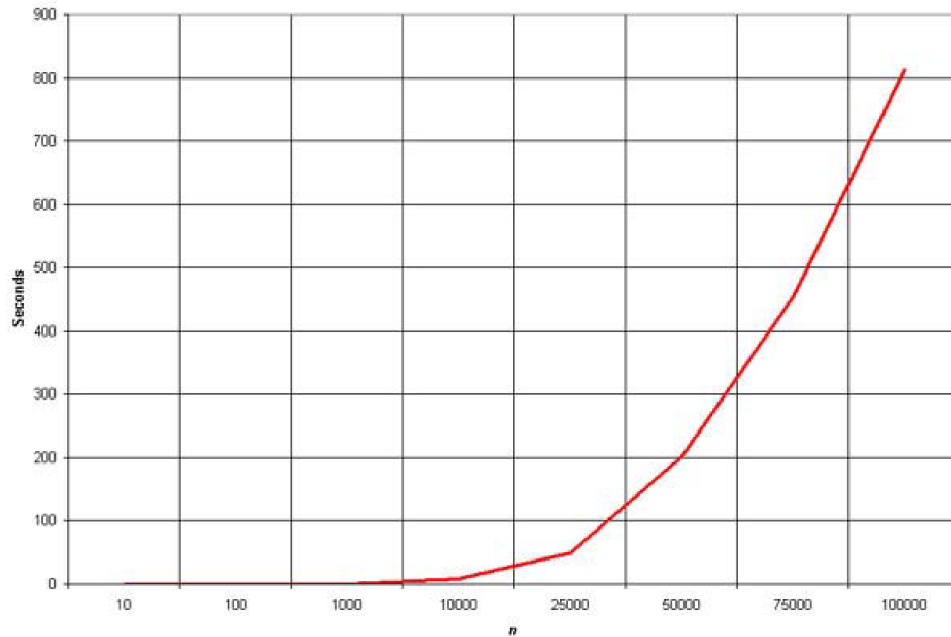
Figure 5. Bubble Sort Efficiency

The graph clearly shows the n2 nature of the bubble sort.
A fair number of algorithm purists (which means they've probably never written software for a living) claim that the bubble sort should never be used for any reason. Realistically, there isn't a noticeable performance difference between the various sorts for 100 items or less, and the simplicity of the bubble sort makes it attractive. The bubble sort shouldn't be used for repetitive sorts or sorts of more than a couple hundred items.

```
void bubbleSort()
{
    int temp;
    for(long i = 0; i < length; i++)
    {
        for(long j = 0; j < length-i-1; j++)
        {
            if (list[j] > list[j+1])
            {
                temp        = list[j];
                list[j]     = list[j+1];
                list[j+1]   = temp;
            }
        }
    }
}
```

Code five

3. RESULTS SORT COMPARISON

After the development of the algorithms, it is good for us to test how fast they can be. In this part we developed a simple program using the code above to generate a basic benchmark, just to see how much time they can use to sort a list of integers. An important observation about the code is that Shell sort and Heap Sort algorithms performed well despite the length of the lists, on the other side we found that Insertion sort and Bubble sort algorithms were far the worse, increasing largely the computing time.

ALGORITHM	BEST CASE	AVERAGE CASE	WORST CASE
Bubble Sort	$\Omega(n)$	$\Omega(n^2)$	$\Omega(n^2)$
Selection Sort	$\Omega(n^2)$	$\Theta(n^2)$	$O(n^2)$
Insertion Sort	$\Omega(n)$	$\Theta(n^2)$	$O(n^2)$
Heap Sort	$\Omega(n \log(n))$	$\Theta(n \log(n))$	$O(n \log(n))$
Quick Sort	$\Omega(n \log(n))$	$\Theta(n \log(n))$	$O(n^2)$
Merge Sort	$\Omega(n \log(n))$	$\Theta(n \log(n))$	$O(n \log(n))$
Bucket Sort	$\Omega(n+k)$	$\Theta(n+k)$	$O(n^2)$

Figure 6. Results of comparison

In this section, we are going to conduct three sets of tests. The first will have 100 random numbers, the second will have 1000 and the third will have 10,000.

Table 6. Results of comparison

Sorting Algorithm	Test 1 (100)	Test 2 (1000)	Test 3 (10000)
Bubble Sort	Min: 0.01008 seconds Max: 0.0206 seconds	Min: 1.0242 seconds Max: 1.0558 seconds	Min: 100.922 seconds Max: 102.475 seconds
Insertion Sort	Min: 0.00306 seconds Max: 0.00650 seconds	Min: 0.0369 seconds Max: 0.0562 seconds	Min: 100.422 seconds Max: 102.344 seconds
Selection Sort	Min: 0.00556 seconds Max: 0.00946 seconds	Min: 0.4740 seconds Max: 0.4842 seconds	Min: 40.831 seconds Max: 41.218 seconds
Quick Sort	Min: 0.00482 seconds Max: 0.01141 seconds	Min: 0.0370 seconds Max: 0.0383 seconds	Min: 0.401 seconds Max: 0.420 seconds
Merge Sort	Min: 0.00444 seconds Max: 0.00460 seconds	Min: 0.0561 seconds Max: 0.0578 seconds	Min: 0.707 seconds Max: 0.726 seconds
Heap Sort	Min: 0.00489 seconds Max: 0.00510 seconds	Min: 0.0704 seconds Max: 0.0747 seconds	Min: 0.928 seconds Max: 0.949 seconds

The $O(n^2)$ Algorithms (Bubble and Insertion Sort) reacted very poorly as the number of tests went up to 10,000. At 10,000 numbers the other Algorithms were on average, over 100x times faster.

On the test cases with just 100 numbers, the O(n2) Algorithms were faster than the O(n.log(n)) Algorithms. With every 10x increase in the amount of numbers, the O(n2) Algorithms completion time increased by 100x.
Heapsort is fastest Algorithm with a space complexity of O(1).
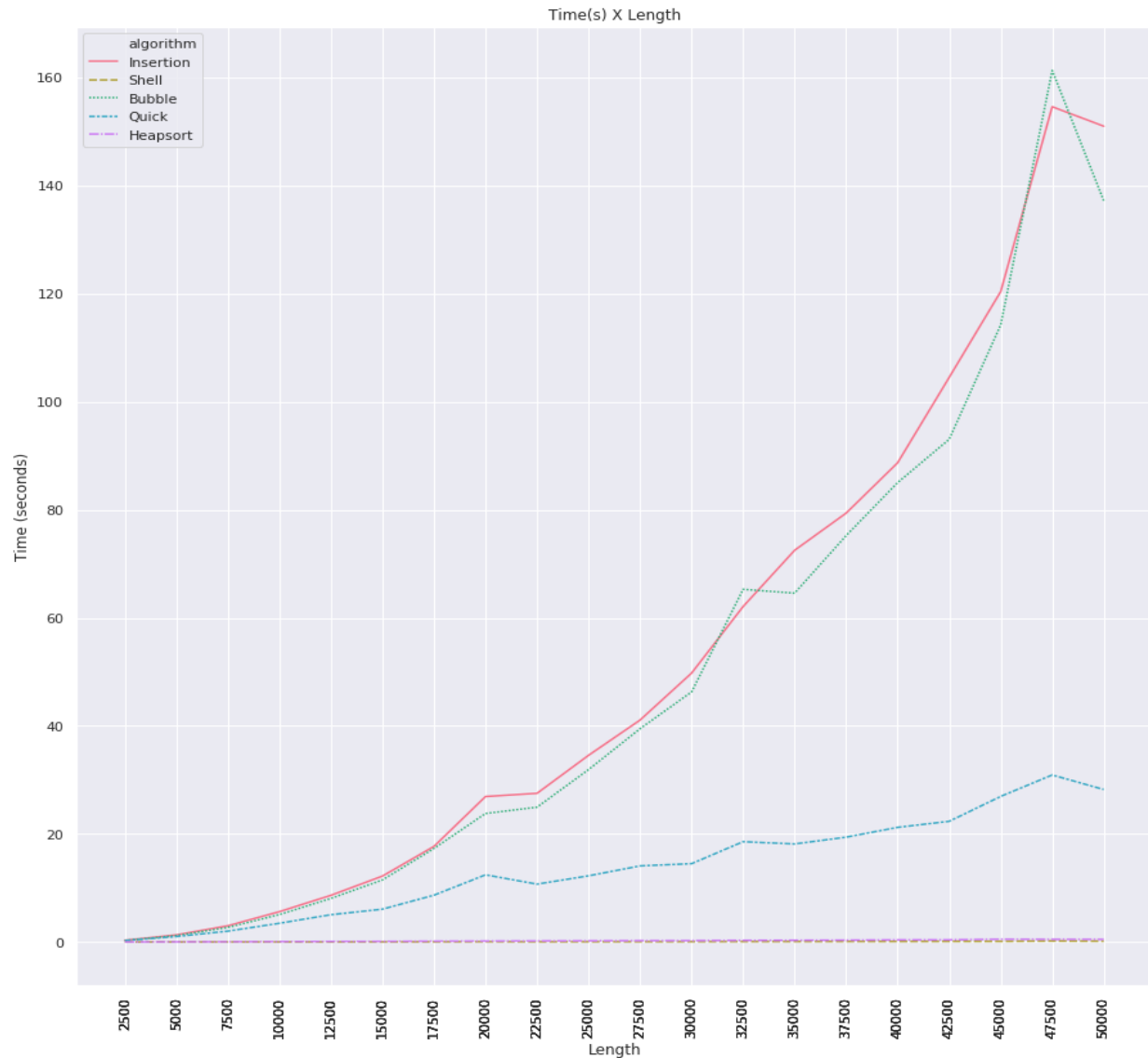
Figure 7. Results of comparison

4. CONCLUSION

In this study, we have studied various sorting algorithms and their comparison. There are advantages and disadvantages to all algorithms. To find the running time of all sorting algorithms, we used C++.

REFERENCES

1. Galler, L., Kimura, M. (2019). Sorting Algorithms, LAMFO [Online].Available at https://lamfo-unb.github.io/2019/04/21/Sorting-algorithms/ (Accessed 2 July 2021).
2. Kansas State Polytechnic (2015). Sorting Properties [Online], Available at http://faculty.salina.k-state.edu/tmertz/Java/324sorting/sortingproperties.pdf (Accessed 3 July 2021)
3. Wikipedia (2015). Sorting Algorithm [Online], Available at https://en.wikipedia.org/wiki/Sorting_algorithm (Accessed 1 July 2021)
4. Geeks for Geeks (2018). Sorting Algorithms [Online]. Available at https://www.geeksforgeeks.org/sorting-algorithms/ (Accessed 2 July 2021).
5. Moore, K., Pilling, G., Khim, J., Kappel, T., Takvam, K. (2021). Sorting Algorithms, Brilliant [Online]. Available at https://brilliant.org/wiki/sorting-algorithms/ (Accessed 4 July 2021).
6. Shell Sort Algorithm (2018). Programiz [Online]. Available at https://www.programiz.com/dsa/shell-sort (Accessed 4 July 2021)
7. Chauhan, Y., Duggal, A., (2020). Different Sorting Algorithms comparison based upon the Time Complexity. ResearchGate [Online]. Available at https://www.researchgate.net/publication/344280789_Different_Sorting_Algorithms_comparison_based_upon_the_Time_Complexity (Accessed 5 July 2021).
8. Software Testing Help (2021). Introduction To Sorting Techniques In C++ [Online]. Available at https://www.softwaretestinghelp.com/sorting-techniques-in-cpp/ (Accessed 5 July 2021).
9. Allain, A. (2019). Sorting Algorithm Comparison. CProgramming.com [Online]. Available at https://www.cprogramming.com/tutorial/computersciencetheory/sortcomp.html (Accessed 6 July 2021).
10. SanFoundry (2021). C Program to Implement Shell Sort [Online]. Available at https://www.sanfoundry.com/c-program-implement-shell-sort/ (Accessed 7 July 2021).
11. Goodrich, T. M. (2018). Insertion Sort and Shell Sort [ebook] Irvine: University of California. Available at https://www.ics.uci.edu/~goodrich/teach/cs260P/notes/Shellsort.pdf (Accessed 7 July 2021).
12. Phongsai, J. (2009). Research Paper on Sorting Algorithms. Computer Science and Engineering, IIT Kanpur [Online]. Available at https://www.cse.iitk.ac.in/users/cs300/2014/home/~rahume/cs300A/techpaper-review/5A.pdf (Accessed 8 July 2021).
13. Programmer Sought (2021). Inserting Sort, Shell Sort, Heap Sort and Quick Sort [Online]. Available at https://www.programmersought.com/article/18836491585/ (Accessed 9 July 2021)

THE CAPSULE - AN ARTIFICIAL INTELLIGENCE POWERED CHATBOT IN HUMAN RESOURCES MANAGEMENT SYSTEMS

Damir Rahmani[1], Hiqmet Kamberaj[2,3]

[1,2]Department of Computer Engineering, Faculty of Engineering, International Balkan University, Skopje, North Macedonia

[2]Department of Telecommunication and Network Engineering, University of New York Tirana, Tirana, Albania

Abstract. *Artificial Intelligence (AI) has an impressively wide range of capabilities, such as making decisions in real-time based on computing technologies and various predefined algorithms. The departments of Human Resources (HR) will also experience the impact of AI. HR professionals understand the importance of powering the human mind and machine learning mixture for a smooth workflow and intuitive work environment. Based on pre-installed algorithms and powerful computational technologies, AI can make decisions in real-time. Through an HR department that incorporates the human dimension and AI, businesses will provide their applicants and workers with an improved experience. Additionally, businesses can better understand their target market and promote result-oriented sales strategies by employing AI technology, which can learn and adapt automatically based on data analysis to provide more refined responses to circumstances. In this study, we focus on the issues such as how AI affects the HR department, the involvement of AI in recruitment and onboarding, employee experience, process improvement, and the automation of administrative tasks. Artificial Intelligence may need a considerable amount of data for proper storage and management to function effectively. Companies would need additional staff to run the sophisticated program and manage it. Using AI software to evaluate the collected data and leave the decision-making to the human workers would be the perfect method for employing AI in HR. Examining the areas where AI may be beneficial before introducing AI within HR operations may increase efficiency and decrease operating costs if the primary purpose is to enhance the overall employee experience. Our study highlights the use of Chatbots and their implemented technologies. Here, the main focus will be on designing and using an Artificial Intelligence-powered Chatbot in HR. Also, we focus on how they can simulate a conversation as a human.*

Keywords: *Artificial intelligence; human resources management; chatbots.*

1. INTRODUCTION

1.1 Artificial Intelligence

Technology is rising quite quickly in today's world, and we are getting in touch every day with numerous new developments. AI is one of the booming computer science innovations, prepared to create a new revolution by creating intelligent robots. AI is now everywhere around us, and its advance of knowledge is quickly proceeding [21]. It currently deals in several subfields, ranging from general to particular, such as self-driving vehicles, playing chess, proving theorems, playing music, drawing, and other fields. AI is an exciting and universal computer science area that will have a broad scope in the future. AI appeals to make a machine work like a human being. Artificial intelligence consists of two terms, Artificial and Intelligence, where Artificial defines *human-made* and intelligence *thinking ability*. Hence, AI determines an artificial power of thinking. Artificial intelligence occurs when a computer may provide human-based skills, such as understanding, reasoning, and problem-solving. We do not need to pre-program a computer with AI to do any work, even though we can create a machine with programmed algorithms that can work with our intelligence, and that is the awesomeness of AI [1, 2].

In the last few years, a modern approach towards the usage of artificial intelligence is discussed, based on bottom-up techniques by taking the basic building blocks of intelligence and placing them together in specific situations for a definite time with the purpose for those elements to adapt and learn how to handle those situations, which is known as the Situational approach [3]. That is done multiple times, and the results are collected, analyzed, and compared to conclude [4]. They are mainly based on intelligent agents whose behavior is defined correctly in their environment.

---

[3] Corresponding author email address: hkamberaj@ibu.edu.mk

The intelligent behaviour of the agent is achieved due to its interaction with the environment via the connecting of simple process elements that work in parallel (like neurons in the brain). That is the fundamental idea according to which artificial neural networks function. There are different aspects of the behaviour, such as sensing and movement (sensory-motor coordination), recognition of the current situation (classification), decision-making (selection of an appropriate response), and performance (execution of the response). Furthermore, the agents' behaviours can range from fully conscious (cognitive) to the unconscious (reactive), from overt (done openly) to covert (done mysteriously), and from voluntary (the agents act according to their own free will) to involuntary (done without conscious control or done against the will of the agents) [5].

The first fundamental concept of modern artificial intelligence is to consider the way the biological brain works in terms of essential functions, development, and adaptation over time. The second concept is based on relatively simple models of the building blocks of the brain, which are emulated by technological design using electronic circuits or using a computer program designed to simulate the behavior of the building blocks of the brain. These artificial building blocks connect in different ways to act similarly to a brain [6]. Neural networks are the means which are used to simulate the working of a brain. A neural network is a set of interconnected simple process elements, units, or nodes, whose functionality is based on biological neurons [7].

An agent is an object that can perceive its environment through sensors and act on it using effectors. That is more applicable in describing a human or animal; however, it is also helpful in describing the actions of an agent representing a mechanical system or other complex systems, such as a chaotic system, whenever the agent-oriented perspective is used. Therefore, the research of intelligent agents is at the heart of the problem in AI. The initial goal is to build an intelligent supercomputer, but the ultimate goal is to achieve artificial intelligence [8]. The fundamental requirement is to do the right thing; that is, to perform actions where the agent will be most effective. The term *performance measure* determines the agent's success criteria, which is performed objectively. In other words, we, as outside observers, define a standard on what it means to be successful in the environment, and this standard is used to measure the agent's performance. Based on those criteria, we can extract the definition of an intelligent agent. For every possible sequence of perceptions, the ideal agent should take any actions for which it expects to maximize its measure of performance, based on evidence obtained through a sequence of perceptions and any built-in knowledge it possesses. The behaviour of the agent depends solely on the sequence of perceptions up to a certain point.

Artificial intelligence technology aims to create an agent program, which is a function that implements agent mapping from perception to action. The assumption is that the program will run on some computer device which we refer to as architecture. The program is selected so that the architecture accepts and executes it. Intelligent systems decompose into a set of independent semi-autonomous modules, representing separate agents, which are often conceived of as running on individual devices with their processing threads. The architecture can be a simple computer, including hardware for particular purposes such as picture processing hardware or audio input filtering devices. It may include software that allows the isolation between the core computer and program agent to be programmed at a higher level, such as object-oriented programming. In general, the architecture allows the program to access the preceptors from the sensors, run the program, and supply the program's responding actions to the effectors. In the relationship between architecture and the program, the agent can be seen as the architecture plus the program.

Overall, complex and intelligent behaviour is achieved via interactions of simple entities that represent semi-autonomous agents. Some agents have little or no knowledge of what other agents are doing in such a structure. Agents are relatively independent but still influenced by other agents in terms of achieving goals in the environment. The final result can be achieved by only one agent or a set of agents. Based on the so-called agent's space topology, different agents are defined as collaborative agents, collaborative learning agents, interface agents, intelligent agents, internet agents, reactive agents, and hybrid agents [9]. These agents represent intersections of the sample space topologies of different agents, based on their properties, such as cooperating learning agents and autonomous agents.

An autonomous agent has an understanding and estimation of how its actions could influence its future observations. The last feature listed distinguishes autonomous agents from other software. The assumption is that some generally intelligent systems should be autonomous agents because generating knowledge is the main factor needed. Learning requires senses, often also taking specific actions. An autonomous agent is suitable for learning, incredibly human-like learning. To perform all of this, the agent must have built-in sensors for senses, effectors to act, and primitive

motivators, which motivate its actions. Sensors, effectors, and motivators are primitives that must be built into the agent. There must be the option and possibility for them to develop with time inside of an agent [10].

It is also possible to create an agent system so that all agents inside that system have the same strength and capabilities. On the other hand, some agents can override the decisions of other agents. That is the case in a layered architecture where the higher priority level agents override the agents' actions or decisions with lower priority.

1.2 Artificial Intelligence in Human Resource Management

Nowadays, most professionals recognize now that intelligent technologies are actively transforming workplaces. AI is being used in almost every discipline in our daily life, and hence the human resources management departments are the following targets. A recent study conducted by Oracle indicates that human resources professionals believe that AI offers opportunities for acquiring new skills and gaining more leisure time, helping HR professionals extend their existing positions and be more strategic within their organizations [22]. However, 81% of HR leaders who responded to the survey considered it is challenging to keep up with the rate of technical change at work. Therefore, it is more critical for human resource experts to consider the way AI is reshaping the market.

Artificial Intelligence technology enables computers to learn and make or prescribe decisions from previously collected data. AI can streamline operations and increase the performance of human resource management in a variety of ways [11]. Machines are not intelligent, but they can be fast and accurate by providing them with the appropriate knowledge and technology. Although companies incorporate AI into their human resource systems at different levels, it is apparent that as the technology becomes more broadly adopted, it will have a long-term effect on the field. Therefore, HR professionals should take on technologies and try to adapt them to different roles.

Many companies are now incorporating AI technologies into their recruitment activities. According to Deloitte's 2019 Global Human Capital Trends report, only 6% of respondents believed their company had best-in-class recruiting processes in technology, while 81% felt their organization's processes were standard or below standard [23]. Therefore, companies have many ways to adapt their methods and benefit from cutting-edge technologies. AI will help not just the recruiting company but also the potential candidates during the recruitment process. AI technologies, for example, will streamline application procedures by developing more user-friendly forms that a potential candidate is more likely to complete, thus reducing the number of abandoned applications. While this approach has streamlined the human resources department's position in recruiting, it also provides more straightforward, more accessible, and more substantive processes on the candidate's side, which has been shown to increase the applicant's success rate [12].

Furthermore, AI plays a significant role in nominee rediscovery by assessing the current pool of candidates and recognizing other suitable candidates for new positions in the future. Rather than wasting time and money looking for new hires, HR experts will use this technology to find eligible candidates more efficiently and conveniently than ever before. The onboarding process continues after recruiting managers have determined the right fit for their vacant vacancies. This method would not have to be limited to regular business hours with AI aid, which is a significant change over previous onboarding procedures. Instead, AI technology enables recruits to access human resources assistance anytime and from any place by using chatbots and remote support applications. This transition allows workers to get through the onboarding process at their speed and eliminates logistical pressure, and, in most cases, results in quicker integration [1].

HR experts may use artificial intelligence to increase organizational mobility and job satisfaction and improve the recruitment process. Human resources teams can now more reliably gauge workforce retention and work satisfaction than ever before due to customized communication surveys and employee recognition programs. That is extremely helpful given the importance of understanding workers' overall needs. On the other hand, there are many primary operational advantages of providing this knowledge as well. According to a recent study, some AI software may analyze critical metrics of employee performance to determine those who should be promoted, thus driving internal mobility. That has the potential to dramatically lower talent recruiting costs while still increasing employee retention rates. This technology, however, is not limited to finding prospects for internal promotion. It can also determine who a team is most likely to leave. Having this information as quickly as possible helps HR experts deploy retention measures until it is too late and will help minimize employee turnover strategically. [12]

Incorporating AI into different human resource systems is a primary advantage compared to other fields and industries. By automating low-value, conveniently repeatable routine activities, HR practitioners gain more time to devote to corporate strategic planning. As a result, the HR department is willing to become a proactive business partner within their organizations. Innovative technology can simplify procedures such as profit administration, pre-screening applicants, interview preparation, and more. Each of these activities is critical to an organization's ultimate performance; carrying out the tasks involved in those procedures takes time. The burden of these responsibilities often ensures that HR practitioners have less time to devote to supporting their workers in more impactful ways. Using AI tools to simplify administrative activities can help alleviate this burden. According to an Eightfold report, HR staff who has used AI software handled administrative activities 19% more efficiently than departments who did not use such technology [24]. HR experts will dedicate more resources to strategic planning at the corporate level than the time saved [1].

While it is evident that AI will positively impact human resource management in the years ahead, HR experts should also be mindful of the potential challenges. One of the apparent challenges revolves around making AI easier and better to use. The most common deterrent to using AI at work is apprehension about security and privacy. Furthermore, according to the previously mentioned research conducted by Oracle, 31% of the respondents would instead communicate with a person in the workplace rather than a computer. HR experts must be prepared to resolve these issues by keeping familiar with trends and technologies as they grow and improve [12].

2. RESEARCH METHODOLOGY

2.1 Objectives and hypotheses

This study aims to create a project regarding an AI interviewer. Besides, we aim to create a Demo version of the system with basic decision-making skills and analysing opportunities. In that Demo version, we will create a Chatbot that talks with the end-user using natural language to simulate human interaction. It should contact the user, recognize the input from the user, and connect the user needs to the proper contexts, meaning that the *bot* is trained to answer the user using a Machine Learning (ML) approach. A so-called dictionary is created with different intents, such as the *tags*, *patterns*, *responses,* and *context* explained in the following.

The following will discuss the software and platforms used for the Demo creation in more detail. In the process of hiring employees, Artificial Intelligence is implemented with several hypotheses, as follows:
1. AI should only be used for automated tasks.
2. AI should be responsible for the entire procedure of hiring new employees, even the final decision-making.
3. Empathy and emotional bias should not play a role in the employee recruitment process.
4. "The Capsule" as an AI interview system is applicable right away.
5. In the future, AI will play an essential role.

2.2 Artificial Intelligence Bots

AI bots represent self-learning bots that are developed using natural language processing and machine learning. The process of developing and training AI bots takes much time and much data. On the other hand, AI bots will save a significant amount of time and resources in the long term. AI bots' ability to self-learn saves resources because, unlike rule-based bots, they do not need to be revised regularly. AI bots can be designed to understand various languages and overcome the problems of personalized communication. AI bots can learn to read customer's emotions using deep learning. These bots can communicate with customers depending on their mood. AI bots can help deliver customized customer support and increase customer loyalty by constantly learning. Since AI bots can manage customer requests from start to finish without requiring human intervention, they can provide round-the-clock customer service.

AI can make bots intelligent, but it cannot teach them to understand the meaning of human experiences. Human behaviour is primarily context-driven. Humans, for example, may alter their speech style depending on the situation. They use more straightforward vocabulary and shortened sentences when dealing with young children. Furthermore, when human employees deal with customers, they adopt a more formal tone. Since bots cannot comprehend human context, they interact in the same manner with everyone, regardless of the factors present. The potential of AI bots to

self-learn can seem beneficial to organizations, but it may also be problematic at times. AI-driven bots cannot make correct decisions, and as a result, they can learn what they are not meant to do. The development of AI-driven chatbots started a long period ago.

2.3 Chatbots

Nowadays, chatbots are used almost everywhere [21]. There are multiple definitions of a Chatbot. Chatbots are present for a long time; however, they have only recently gained attention from consumers and organizations. The shift in understanding for chatbots and conversational interfaces was primarily driven by advancements in artificial intelligence, machine learning, and the growing prevalence of messaging applications. Chatbots are being found in a variety of businesses and for a variety of purposes. If we focus on the history of chatbot development, the conclusion can be made that it all started with the Turing test and development of the first chatbot known as Eliza until today, where we have intelligent bots in our pockets. A timetable for the development of chatbots can be introduced by focusing on some time stamps that played an important role. The main emphasis points of Chatbot developments are summarized in Ref. [13]. Chatbots are mainly used nowadays for two main reasons: personal usage, and the second one is the usage of chatbots to improve an organization's business usage.

Particular prerequisites of chatbots need to be satisfied, such as NLP – natural language processing, NLU – natural language understanding, NLG – natural language generation. Additionally, two important things to consider, which are not an integral part of the chatbot design, are application programming interfaces (APIs) and the user experience (UX).

There are different ways provides to classify Chatbots [13]. The classification is usually done based on a particular problem. Two initial starting points are mainly used: problems trying to be solved and functionalities trying to be incorporated. According to these two starting points, several Chatbot groups can be identified, as described in [13].

The heart of Chatbot development is its architecture. The design involved in developing a Chatbot varies significantly depending on its usability and business operations background. The necessary design is determined by the kind of domain the Chatbot would have. Two basic models on which all the chatbots can be traced include the *generic-based model* and *retrieval-based model*. With the generic-based model within it, traces of AI can be identified. There is a training model within this concept, and the generic-based model is contextually based. It is a type of model where machine learning is used to generate responses. Information/response is generated after understanding and analysing the input from the user. The retrieval-based model is characterized by specific predefined rules based on which the response is generated. The process goes as follows: the user sends a message, from which the context of the message is processed, the context is checked based on the predefined rules, according to which there exist predefined responses, if the context is valid, a response is sent back. One example of the usage of this model can be seen in situations when the user has to press a specific key to continue. This model does not require any usage of AI or machine learning. The developer predefines the rules and responses.

To conclude the architecture of chatbots, there is a model defined from which all chatbots can be developed. This model is known as the basic block diagram for any type of Chatbot, as shown in Figure . A message/input from the user is sent from the presentation layer. The presentation layer represents the host platform of the Chatbot. After the message is extracted, it reaches the machine learning layer. Inertly the natural language processing and understanding perform. After that, a decision engine is triggered. The decision engine is mainly a part of the Chatbot based on the retrieval-based model, meaning that the next step is determined according to some predefined rules. If we have a retrieval model, then the message is sent to the data layer is where the response context is decided and sent to the natural language generation for competition. In the generative generative-based model, the data layer is not triggered. The response is created following AI and machine learning, and it is sent to the natural language. Natural language generation converts the response in a form understandable to the user and sends it to the presentation layer.

The responses can be generated in various ways, known as the response generation mechanism of chatbots. This mechanism centers around two essential parts: pattern-based heuristics and intent classification using machine language.
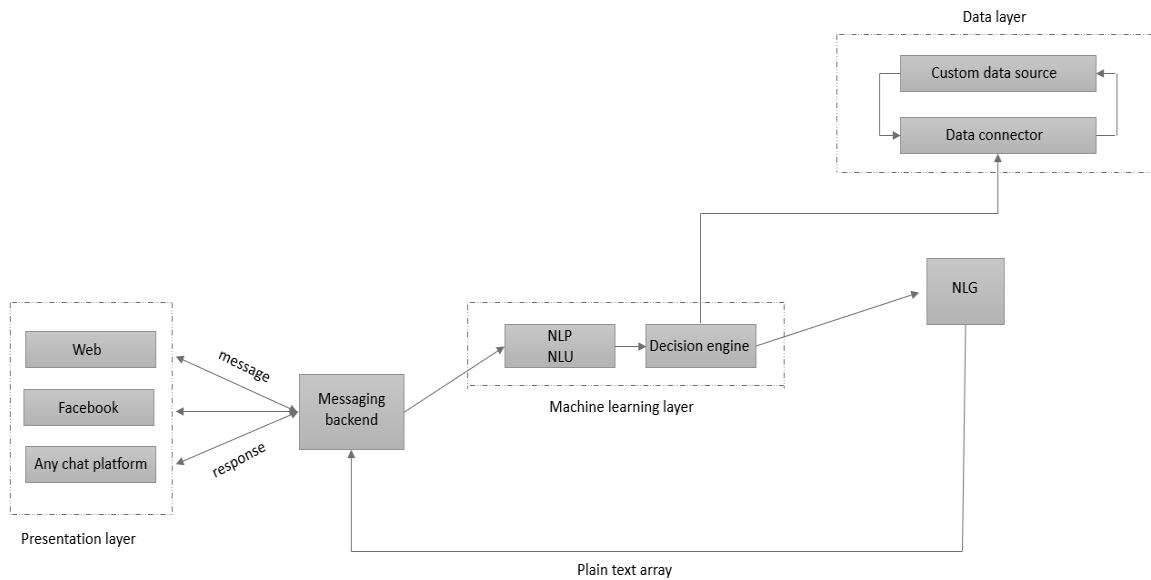
Figure 1. Basic Block Diagram Model

2.4 Dialogflow

The Dialogflow console is used to develop, construct, manage, finalize, and test agents. [14] Dialogflow represents a human-computer interface technology focused on Google developers' natural language. This Google-powered platform allows developers to build text-oriented conversation interfaces in various languages to respond to consumer concerns. Dialogflow is using machine learning as its foundation. Dialogflow agents represent virtual agents that conduct discussions with end-users. They are modules for understanding natural language coming used for recognition of human language complexities. Dialogflow converts text or audio extracted from the interaction with end-users into structured data, which is the format understandable by the platform. A Dialogflow agent is like a call center agent for a human being. They both need to be trained in handling the planned chat situations, and there is no need for that training to be too explicit in the preparation. Agents are often used as high-level configuration and data containers. Agents in Dialogflow can be created from scratch by the developer, but the platform exists predefined agents. These are known as prebuilt agents. Prebuilt agents are a group of agents for general use by Dialogflow. Today, the limitations with the usage of prebuilt agents are that they are only available for the US region, and they are only provided in a few languages. Prebuilt agents are not created; they are imported to the platform from the database provided by it.

Intents are the crucial piece in creating intelligent chatbots. For every keyword/phrase/text being forwarded to the chatbots, something known as that conversation intends. An intent categorizes an end user's intention for one conversation turn. For each agent, developers define multiple intents. Different combinations of intents are used to handle entire conversations. Intents include four essential components, such as training phase, actions, parameters, and responses.

The training phase includes example phrases regarding what the input can be from the end-user. If the end-users input matches or is similar to these phrases, the intent of this phrase matches the input, and a specific action will be triggered. Not every possibility of the input phrases needs to be defined because the Dialogflow platform provides built-in machine learning that can match phrases that resemble one another and correctly recognize the context. For each intent, actions can be defined. These actions are triggered when intent matching occurs. The process of intent matching also includes exactions of specific values from the user input. These values are known as parameters. Each parameter has a type, known as entity type, that dictates how the data is extracted. Parameters are data that have a

logical background and are used to define precise responses. Responses are given as text, speech, or visual graphics. Responses are the answer generated by the platform and send back to the end-user. Responses are used to answer some questions the -user has, as the end-user for additional information or simply ending the conversation.

Entities dictate exactly how data from an end-user expression is extracted. There exist two types of entities, namely predefined and custom. Here, predefined is an entity created by the system, and the developer defines custom.

Context represents the current state of a user's request that allows the chatbots to transfer information between intents. It is used to create a logical whole from multiple intents. Events are used to trigger specific intents. Usually, intents are triggered by the user input, but intents are also triggered from the backend with events. There are two types of events: platform-dependent events and custom events.

Chatbots can be created using all the parts mentioned above, but at that point, the chatbots are still not functional. A crucial process is the training to make it functional and ready to be launched. Nowadays, AI and machine learning are involved in the chatbots' architecture, making the training process more general and simplified. The training at this point of the technology development stage should be just done in a broad way to define context, but the chatbots define all the specifics by finding patterns and analyzing the context. The training process is initiated by defining the chatbots' specific use case. The use case represents the specific problem the AI-enabled Chatbot needs to be able to solve. If the AI Chatbot cannot understand what the end-user wants, a frustrating user interface will be created. Very particular intents need to be created that serve a given objective to prevent this and understand how to teach a Chatbot. The usefulness of the AI Chatbot relies explicitly on the use of actual language in the sample expressions. The usage of several different terms to evoke each of the intents during the creation and testing of the Chatbot is essential. Many iterations are required to ensure all of this. Continuous updating and defining new keywords to invoke intents is crucial to ensure an overall usage rate of the bot. The whole training process must not be conducted only by the developers, but a wide variety of testers is beneficial.

3. RESULTS AND ANALYSIS

3.1 Data collection methods

Two methods are discussed to collect data. In the first method, the data were collected using the quantitative method through the Google forms platform. This type of data collection was used to quantify attributes, attitudes, and several defined variables with a motive to back or oppose a specific hypothesis of a specific phenomenon. Later on, computational, statistical, and mathematical tools derive results from the collected quantitative data. The second method used is the face-to-face interview method based on a predefined structured questionnaire. The questions for each questionnaire are prepared and defined in this study, as described in Refs. [12, 15].

Google form method was selected to collect data from a variety of people. This method was used to compile all the standard survey fields (text, dropdown, scales, and multiple-choice questions). The Google form used for our specific case was constructed from 19 questions (both regarding respondent information and topic-related questions) and one field where the respondents can express their personal opinions or comments.

The interview regarding our research was conducted with a director working in an IT company in Vienna, Austria, who has already applied some form of artificial intelligence in their structure, and they also plan to extend it. The interview was constructed of eleven questions. The questions are based on his subjective opinion regarding the usage of AI in the hiring process, the implementation of AI in the HR department in the specific case of that company, and their opinion regarding further usage of AI in the HR department as well as the implementation of AI in general.

3.2 Data analysis

We divided data into two groups, namely the Google form data and Interview data. The analysis was performed using the Google forms spreadsheet and data analysis tools. After that, several smaller tools were used to organize the data and draw conclusions from it. After analysing the questions and the answers, the decision has been made to create four subgroups that contain data that is linked and creates a logical whole. The results are shown in Table 7.

Our data confirm that the used sample has a wide variety, which is concluded by analysing the basic information retrieved from the 210 respondents. From Table 7, 4/5 of the total number of respondents are no older than 30. Thus, this shows us that AI, with AI being a reasonably new concept and technology, awakes the interest of reasonably young members of society. That is also confirmed by the fact that 50% of the respondents are students. The sample can be seen as representative because the respondents are spread worldwide, with 50% being from Europe and others being spread in Australia, North America, and Asia. Another indicator of the data's representativeness is that people with different levels of education accomplished, ranging from upper secondary education until doctor degree.

Table 7. Respondent Information of Group 1.

Number of respondents	210	
Age	16-30	81%
	30-40	14.3%
	40+	4.8%
Gender	Male	76.2%
	Female	23.8%
Occupation	Student	50%
	Other	50%
Continent	Australia	5.3%
	North America	19.4%
	Europe	52%
	Asia	23.3%
Level of education	Bachelor degree	61.9%
	Upper secondary education	9.5%
	Master degree	23.8%
	Doctor degree	4.8%

The second group of questions focuses on assessing and measuring the readiness of companies and people to organize and attend job interviews conducted by AI, respectively, as shown in **Table 8**. The results indicate that most respondents have had experiences attending a job interview before. The experience they all had is, conducting job interviews in conditions where human interaction was present. That is reflected in their answer, in which stats show that 90% of the respondents prefer human interaction over AI interaction during an interview. That should be taken with a dose of caution because the AI interaction is discussed just from a theoretical point.

Moreover, also subjective comprehension about AI that the respondents have must be taken into account. An indication that we should answer a dose of precaution is also the answer received from the next question, asking if the respondents think they would be comfortable attending an AI job interview. A drastic percentage drop can be seen, with only 38% of respondents stating that they would not be comfortable in such a scenario. However, the assumption that the awareness regarding AI is still not satisfactory can be made because 34% of the participants

remained neutral regarding this topic. On the contrary, assessing the opinion of AI conducted job interviews from a purely technical point of view, more than half of the respondents agree that AI would make the whole process faster and more efficient. However, they limit themselves firmly because they only perform the "dirty" work from the technical perspective.

Table 8. Preparedness to Conduct AI Interview of Group 2.

Attended job interview?	Yes	90.5%
	No	9.5%
Human interaction or AI during the interview?	Human interaction	90.5%
	AI interaction	9.5%
Would you be comfortable going to a job interview conducted by AI?	Yes	28.6%
	No	38.1%
Do you think AI conducted job interviews more effectively/less time-consuming?	Yes	52.4%
	No	47.6%

Now, let us assume that we are forced to take an AI-conducted job interview. The point here is to make the respondent enter the mindset that they have to take such an interview, and now we want to extract some information from them regarding their opinion and expectation before the interview. **Table 9** presents the results of this assessment. Our data indicate two points to be emphasized. As mentioned, the core of the interview should be influenced by the human factor. The respondents still prefer and demand human interaction during the core process of the interview, but putting the "humanity" aside, they all agree that AI can optimize the whole process of the interview regarding things like analyzing data, scheduling, and similar things. That also confirms that 91% of the respondents think that the final decision should depend on humans.

Table 9. AI opinion Assessment of Group 3.

Does AI increase your chance of getting the job?	Yes	4.8%
	No	71.4%
Do AI interviewers reduce subjectivity?	Yes	61.9%
	No	38.1%
Are you comfortable with the scenario in which AI just accesses your CV and evaluates just your experience?	Yes	52.4%
	No	47.6%
Do you think AI should be used only to narrow down possible candidates but that humans should have the final decision?	Help with decision	90.5%
	Make final decision	9.5%
Would you feel comfortable with AI finding and analyzing all data that can be found online?	Yes	52.4%
	No	47.6%

While constructing this questionnaire, expectations were that respondents will not be "friendly" towards the idea of the whole process being automated and that AI should be implemented and applied. Thus, an additional section has been created that deals with and tries to understand the reasoning. The main things that tried to be understood are why there is a general opinion that empathy plays such a crucial role. The results are summarized in **Table 10**. From

Table 4, the respondents just confirmed the predictions, with 81% of them stating that human empathy plays an important role, 52% of respondents think that they would be negatively affected by the fact that the AI conducted interview is not natural and artificial. There is also an exciting conclusion gotten here. People generally tend to regard human interaction kind of in only a positive light, especially when comparing humans and machines. They tend to disregard the fact that people are emotionally driven contrary to machines, and there are millions of different personalities, then people tend to act unpredictably. Also, subjectivity plays a huge role as well as discrimination on various grounds.

Table 10. Emotional Intelligence of Respondents of Group 4.

Should Human empathy influence the final decision?	Yes	81%
	No	19%
AI interviewers being not natural and simulated is affecting you during a job interview?	Yes	52.4%
	No	19%
Do personality traits have high importance during a job interview?	Strongly agree	57.1%
	Agree	33.3%
	Neutral	4.8%
	Disagree	4.8%
	Strongly disagree	0%
If you find yourself in an uncomfortable situation during the interview and cannot present yourself in the best light during a specific situation, do you think the human ability to understand and show empathy is a crucial advantage over AI?	Yes	90.5%
	No	9.5%

The final thing regarding this group of questions to be pointed out is the question that tries to understand the influence of personality traits on making decisions. The respondents were asked to choose one of the options on the 5-point Likert scale, ranging from strongly agree up to disagree strongly. The results are summarized in **Table 11**. Our results indicate that most respondents agree that personality traits have high importance during a job interview. Sometimes, they can even overshadow the actual technical qualifications a candidate should possess.

Table 11. Emotional Intelligence of Respondents Filtered.

Do personality traits have high importance during a job interview?	Strongly agree	57.1 %		Agree	90.4 %
	Agree	33.3 %	→		
	Neutral	4.8 %			
	Disagree	4.8 %		Disagree	4.8 %
	Strongly disagree	0 %			

The analysis regarding the interview has shown a higher degree of readiness to implement and adapt the usage of AI in the HR department and even generally in companies for other purposes. Some points of emphasis required to be accentuated are:

- AI will remove mental drudgery. It can do work that a human cannot. Worth developing.
- Automation does not just understand the replacement of human labour with machine labour. It can be understood as a broad application matter, reaches into different spheres. Advantages of automated tasks include increasing efficiency, productivity, decreasing time consumption, and allowing resources to be directed elsewhere. Thus, it enables companies to remain small and agile. The disadvantages mainly include the doubts of what automation means and brings to businesses, workers, and consumers.
- What exactly does it mean is a company ready to implement AI? Regardless of the company size or industry in which it operates, adding automation into a business environment can cause significant shifts in the way an organization conducts itself.
- In modern IT companies, such as the one interviewed works in, AI is primarily implemented in cognitive engagement. Mainly through the usage of chatbots, intelligent agents, and machine learning.
- One interesting thing, coming from an insider in the world of technology, was that even though the usage of AI in the HR department can be time-saving and efficient in the initial stages of recruitment, the final decision should eventually depend on the human factor.
- AI's potential seems limitless; however, could the automation of the entire job recruitment process be done? Also, AI empathy is not sufficient for human empathy. Keeping in mind that people seeking a job can be in an emotionally vulnerable position, in such situations seeking a job can be in an emotionally vulnerable position. There is no reality where machines are effective at respecting and expressing empathy for job candidates.
- The usage of AI in the future will be inevitable. However, humans will play a significant role in the future of AI.
- AI hiring should be transparent and open to challenge. Complex algorithms used in AI can make the selection decision challenging to justify because it makes it almost impossible to understand how the conclusions are made. Therefore, if the selection decision cannot be easily explained, AI could be quickly challenged from a legal perspective.

The general conclusion that can be crystallized from both of these methods is that AI and automation within the HR department should be only used as a helping tool in the initial phases of the recruitment process, in stages such as candidate screening or interview scheduling; however, the final decision should be made by a human.

4. CHATBOT – APPOINTMENT SCHEDULER

A simple chatbot is created in this study that demonstrated how chatbots could be implemented within HR. The chatbots purpose will be to schedule appointments for the organization where the chatbot is used, with possible job applicants. The chatbot functionality logic will accept contact from the end-user, provide the end-user with basic information about the organization (if asked), perform a simple dialogue interaction with the end-user to extract necessary data, and schedule the appointment. Before the appointment scheduling, the time slot availability of the time and date provided by the end-user is checked and compared with the data available in the organization's calendar. If the timeslot is free, the appointment is set. If the timeslot is taken, the end-user is informed and can schedule the appointment for another time. The Chatbot architecture includes the text messenger platform, Dialogflow platform (Chatbot engine), and Backend applications (frequently asked questions about the company database and third party application of Google calendar).

The Chatbot will be a general one, and the different processes will be handled via the intents. The primary intent is the appointment scheduler. Initially, the training phrases are created; they help give the agent guidelines on his problem, which he needs to be managing.

In Figure, the phrases highlighted in yellow are recognized by the system as entities. The entities automatically recognized by the platform are known as system entities. Besides system entities, the developer also has the freedom to define his entities, which can be associated with any given phrase/keyword. In a training phase where all the possible input phrases are listed, responses to those inputs also exist.
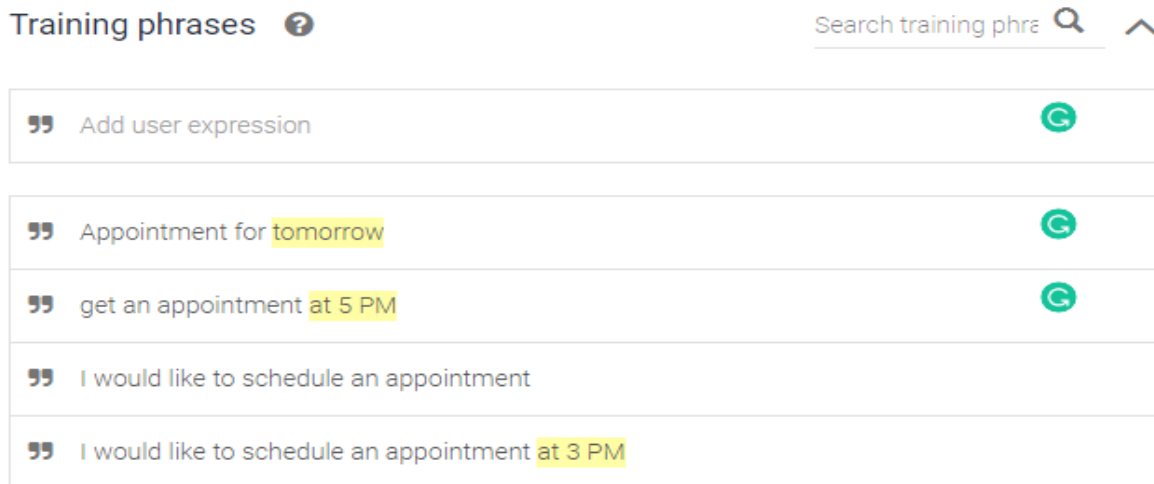
Figure 2. Agent Training

The developer defines responses, and they can be in many forms. For this specific situation, the following response, as shown in Figure , is listed.
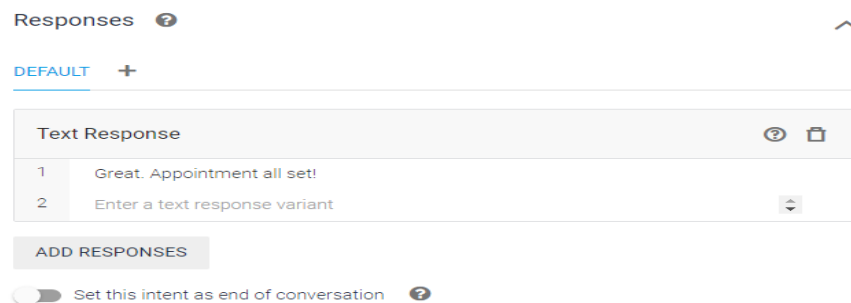
Figure 3. Agent Training

The exciting thing about using the Dialogflow platform in creating chatbots is that AI and machine learning are within it. That means that after a sufficient amount of training data, the chatbot will develop its knowledge base and recognize situations correctly and map them to the correct intents in situations where the input is not covered in the training phase. The machine learning model behind the scenes extracts the critical information and identifies what the intent is trying to say. Within the response section, the defined and detected entities can be used. They are defined in a general way using the $ sign followed by the entity's general name. The problem with this kind of response implementation is that the platform gets into a loophole and cannot generate a proper response when the user input does not contain any keywords defined as entities. A way to fix this situation is to make the entities required, meaning that the user is obligated to provide data identified as entities. The platform is intelligent, and if the user initially does not provide such data, the chatbot will bring the conversation back at the beginning and require the user the needed data. For this purpose, the platform can ask in a general way, which sounds robotic and unnatural, or the developer can define prompts. These are shown in Figure .
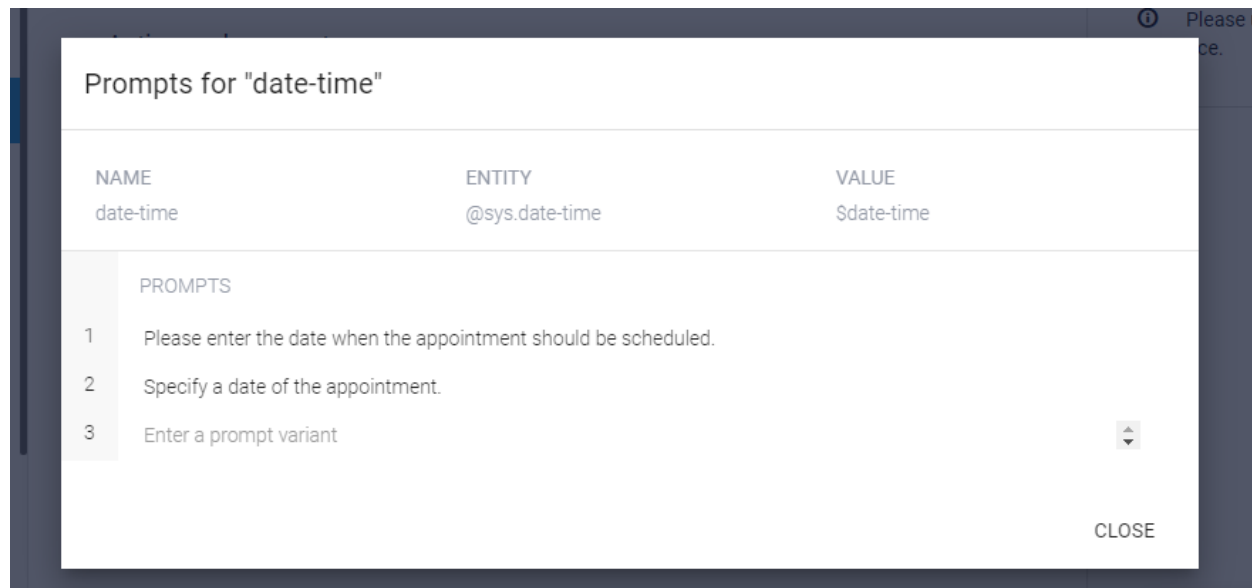
Figure 4. Requiring Entities

For the situation where the user does not respond expectedly, matching with the current context or the general purpose of the chatbot, the Dialogflow platform has a predefined fallback intent. The fallback intent has a default response that helps to return the conversation in the expected format.

A simple schedule appointment bot is created, but how useful is it just existing within the Dialogflow platform? The answer surprisingly is ``not at all". For this reason, Dialogflow enables the developer to integrate the bots created on it with all the big and known platforms, might they be websites, social media, or messenger applications. The chatbot is designed on one platform, but it can be deployed on multiple ones. Mostly the chatbots are integrated with messaging applications. Initially, a representation of how to include a chatbot on some personal websites will be shown. Code one shown below is provided by the Dialogflow platform, which can be integrated into the website's source code.

```
<iframe
    allow="miscrophone;"
    width="350"
    height="430"
    src=https://console.dialogflow.com/api-
client/demo/embedded/78b9b64e-2f83-4367-98cb-3f83f9940aa9>
</iframe>
```

Code one.

The newest version of Dialogflow introduced a new feature known as Knowledge Connector. It enables the chatbot to answer queries based on predetermined sources of knowledge such as websites, FAQs, or knowledge-based articles. The Knowledge Connector is still seen as a beta feature. Thus it needs to be additionally enabled in order to be used and implemented. Inside it, the first thing to do is to create a knowledge base. The benefit of using this feature is to avoid using a significant number of intents and instead replace the ones centered around basic info. The previously created scheduled appointment chatbot needs to check the calendar and schedule the meetings following it. The connection is established via the usage of fulfilments. Fulfillment is a piece of code that connects the Dialogflow agent/chatbot to the backend applications. Fulfilments provide two options, webhooks (for linking servers) and the inline editor, provided by Google, in where there is an option to code the connection between a backend application and the agent directly. (My custom-created code given). There exists the Google calendar API to integrate the calendar into the application.

In the Google cloud platform, the calendar API needs to be enabled to initialize the process. Then at the same platform, a new service is created, under credential, that has the role of a Dialogflow editor. From that service, a JSON key is extracted. The key holds all the necessary linkage information required. On the website calendar.google.com, a new calendar is created, and it is linked with the chatbot by using the data provided by the JSON file. The calendar is edited to be set to the correct location and time zone.

Whenever there is an interaction between the user and the chatbot, the Dialogflow agent handles the entire conversation between the user and the chatbot. Whenever the conversation happens, Dialogflow first assesses the user's intent. If it is ``schedule an appointment'', it will link it to the correct intent. After the linkage creates, back at the Dialogflow platform, the fulfilment code is adapted. Once it comes over, all the data in the form of capturing essential information, such as date, time, type of appointment, is passed to Dialogflow in the form of HTTP request and response. The information passes on specific intents where the developer has previously enabled the fulfilment for that specific intent. Based on every conversation, turn the program analysis to code two shown below.

```
Exports.dialogflowFirebaseFulfillment = functions.https.onRequest((request, response)
=> {
      const agent = new WebhookClient({ request, response });
      console.log("Parameters", agent.parameters);
      const appointment_type = agnet.parameters.AppointmentType;


```

Code two.

Here, the request has all the parameters required as part of the query. Next, an agent is created, which contains parameters. Within these parameters are the critical data is stored. Additionally, a function (in this case, makeAppointment) is created to handle the whole process. This function is passing the information, formatting dates, capturing the data and the time as information extracted from the conversation, and appending it together. The function is shown below on code three.

```
function makeAppointment(agent) {

      // Calculate appointment start and end datetimes (end = 1h from start)

      const dateTimeStart = new Date(new Date.parse(agent.parameters.date.split('T')[1].

      split('-')[0])));

      console.log("expexted String", agent.parameters.date.split('T')[0]
+'T'+agent.arameters.

      time.split('T')[1].split('-')[0] + timeZoneOffset);

      const dateTimeEnd = new Date(new Date(dateTimeStart).setHours(dateTimeStart.

      getHours( ) + 1)));

      const appointmentTimeString = dateTimeStart.toLocalString('en-US',

      { month: 'long', day: 'numeric', timeZone: timeZone }
```

Code three.

In the last part, the checking of the availability of the date and time is performed. Based on this, a response is generated, whether positive (create appointment) or negative (selected date or time not available), as inside code four.

```
console.log("dateTimeStart", dateTimeStart);

console.log("dateTimeEnd", dateTimeEnd);

console.log("appointmentTimeString", appointmentTimeString);

return createCalendarEvent(dateTimeStart, dateTimeEnd, appointment_type).then(( ) =>{

      agent.add('Ok, let me see if we can fit you in. ${appointmentTimeString} is fine!.');

}).catch(( ) => {

      Agent.add('I'm sorry, there are no slots availibale for ${appointmentTimeString}.');

});
```

Code four.

If the process can be performed, an intent map is triggered. Code five presents the mapping. Within it, the intent is handled, and the appointment inside the calendar is triggered.

```
let intentMap = new Map( );
intentMap.set('schedule appointment',
makeAppointment);
agent.handleRequest(intentMap);
```

Code five.

5. DISCUSSION

According to [16], human thought, and hence its understanding, is not established using the algorithms but instead using a trial-and-error basis within some inspiration. That is a different process, and most likely not sharable, that a machine (such as a robot) would employ; for instance, the Turing machines for solving a problem would ignore the human understanding and apply an algorithm indefinitely until hopefully a solution. In contrast, trial-and-error reasoning is based on prior experience, and it is seen as the basis of mathematical achievements. As stated in [16], perhaps it is possible to create a human-like brain within the robotic computer, and then robotic computer brains behave like a human brain when trained based on the initial information to gain some experiences.

The way the brain generates consciousness is still a mystery [17]. Based on the scientific view, consciousness emerges from complex computation among simple neurons that receive synaptic input signals and integrate them to a threshold for bit-like firing. Furthermore, as a network of 10^{11} neurons computing by bit-like firing and variable strength chemical synapses. The brain is the standard model for computer simulations in artificial intelligence.

The brain can account for non-consciousness cognitive functions from the computer viewpoint, including our mental processing and controlled behavior. The complex problem is how cognitive processes are accompanied or driven by phenomenal conscious experience and subjective feelings.

Other issues also suggest that the brain-as-computer perspective may not be completely accurate, and hence other approaches are required. For instance, the conventional brain-as-computer perspective fails to account for the complex problem. Differences between consciousness and non-consciousness processes cannot address non-computable thought and understanding [18, 19]. The causal efficacy of consciousness and any impression of free will cannot be addressed because measurable brain activity corresponding to a stimulus often occurs after responding to that stimulus. The brain-as-computer view depicts consciousness as an epiphenomenal illusion [20].

6. CONCLUSIONS

This study designed a Chatbot for use in the HR department called ``The Capsule". Our study set up a general hypothesis on whether we should use AI in the HR department. Our investigation indicated that AI should only be used for automated tasks. The implementation of AI in such cases has been proven more than beneficial because it brings a higher level of optimization, increases efficiency, and, most importantly, saves time. Also, our study indicates that AI should be responsible for the entire procedure of hiring new employees, even the final decision making. The hiring process of new people should be a versatile process, including many factors, mainly considering the candidates' technical competence and personality traits.

Furthermore, empathy and emotional bias should not play a role in the employee recruitment process. With AI, we automatically exclude any chance of bias being present, which favors the use of AI, that being "emotionless" actually helps, but the vast withdrawal is that empathy lacks.

Moreover, AI will play an essential role in the future. We might even argue that AI will change the world more than anything in the history of humanity. Even today, AI is slowly integrated into most of the spheres of everyday life.

Finally, we conclude that AI should be implemented in the process of hiring employees. Efficiency, optimization, effectiveness, time consumption, all of this can be improved and almost brought to an optimal level. However, the final decision regarding actually hiring people should still be in our hands.

The scope of future implementations is vast in this section of the information technology industry. AI-driven chatbots will undoubtedly play an essential role inside the HR department in analyzing, locating, and hiring new staff. The plan of ours is to try and, with the right resources, financial and technological, actually bring the Capsule idea from theoretical into practical.

Acknowledgments

Software

The chatbot software is in the following repository link: https://github.com/damirrahmani/appoinmentSchedulerBot.

REFERENCES

1. P. R. Daughtery and R. James, Human + Machine: Ramaging Work in the Age of AI, Harvard Business Review Press, 2018.
2. P. C. Jackson, Introduction to Artificial Intelligence, Michigan: Dover, 1985.
3. S. A. Hornby, "The Situational Approach in Language Teaching," *ELT Journal,* pp. 98-103, 1950.
4. I. Y. Burdun, The Intelligent Situational Awareness and Forecasting Environment: A Case Study, 1998.
5. C. Raynolds, Flocks and Herds, "A distributed behavioral model," *Computer Graphics,* pp. 25-34, 1986.
6. K. Warwick, Artificial Intelligence: The Basics, Routledge, 2012.
7. D. B. Basic, M. Cupic and J. Snajder, Umjetne Neuronske Mreze, Zagreb: Fakultet Elektrotehnike i Racunarstva, 2008.
8. Z. Shi, Advance Artificial Intelligence, World Scientific Publishing, 2011.
9. N. S. Hyacinth, Knowledge Engineering Review, Cambridge: Cambridge University Press, 1996.
10. B. Goertzel and P. Wang, Advances in Artificial General Intelligence: Concepts, Architecture and Algorithms, IOS Press, 2007.
11. J. C. Lock, Artificial Intelligence Product Development Trend, 2020.
12. B. Eubanks, Artificial Intelligence for HR: Use AI to support and develope a succesful workforce, Kogan Page, 2018.
13. K. Nimavat and T. Champaneria, "Chatbot: An Overview Types, Architecture, Tools and Future Possibilities," *IJSRD,* 2017.
14. "Dialogflow documentation," 2017. [Online]. Available: https://cloud.google.com/dialogflow/docs. [Accessed 24 March 2021].
15. A. Naqvi, Artificial Intelligence in Human Resources, New York: Sadal USA, 2018.
16. N. K. Bhadra, "The Complex Quantum State of Consciousness," *IOSR Journal of Applied Physics,* pp. 2278-4861, 2017.
17. C. Koch and K. Hepp, "Quantum Mechanics in the Brain," *Nature,* p. 611, 2006.
18. R. Penrose, Shadows of the Mind An Approach to the Missing Science of Consciousness, Oxford: Oxford University Press, 1994.
19. R. Penrose, The Emperor's New Mind: Concerning Computers, Minds and the Laws of Physics, Oxford: Oxford University Press, 1989.
20. D. Dennet, Consciousness Explained, Boston: Little Brown, 1991.
21. James Kellner () *AI is everywhere around us. We need an oath for data.,* Available at: *https://www.aboutsmartcities.com/artificial-intelligence-is-everywhere-we-need-an- oath-for-data-warns-the-scientist/* (Accessed: 12.07.2021).
22. Oracle () AI Is Winning Hearts & Minds in the Workplace, Available at: https://go.oracle.com/LP=86149?elqCampaignId=230263 (Accessed: 12.07.2021).
23. *Deloitte's 2019 Global Human Capital Trends ,* Available at: *https://www2.deloitte.com/global/en/pages/human-capital/articles/gx-human-capital-trends-library-collection.html* (Accessed: 12.07.2021).
24. *Eightfold report,* Available at: *https://eightfold.ai/resources/talent-intelligence-and-management-report/* (Accessed: 12.07.2021).

MODELING NETWORKS OF QUEUES

Amra Feta[1], Andrej Stefanov[2]

[1]amra.feta@ibu.edu.mk, [2]andrejstefanov@ieee.org

[1,2]*Faculty of Engineering, IBU Skopje*

Abstract. *The paper considers the modeling of networks of queues. Nodes in the network are modeled as memoryless queues. The focus is on open networks, since external packet arrivals and packet departures are permitted. Memoryless queues are characterized by a Poisson packet arrival process. This means that the interarrival times are exponentially distributed. The service times are characterized by an exponential distribution as well. Systems of queues could be used to model communication networks. Namely, after leaving one node in the network, there is a certain probability that a packet proceeds to another node in the network. Note that the external packet arrivals are also generated according to a Poisson process. In addition, there is a non-zero probability for the packets to leave the network. The network performance is illustrated by numerical examples.*

Keywords: *networks of queues; queues; modeling.*

1. INTRODUCTION

Computer networks are known as a system of interconnected computers for the intent of sharing digital information. Networking supports communication between two or more programs running on distant computers. In other words, a computer network is a collection of computers which are in some ways connected and exchange data between themselves [1–7]. There are some types of networks which are worth to mention:

- Local Area Networks (LANs) [8].
- Metropolitan Area Networks (MANs) [9].
- Wide Area Networks (WANs) [10].
- Wireless networks [11].

All these networks facilitate the transfer of data among computers. Each network has its own protocols and possibly incorporates different technologies. The routers or gateways interconnect different networks by packetizing the data in the format used by the particular network. The Internet has therefore emerged as a network of networks [12–15]. More recently, the Internet of Things (IoT) has appeared that has the ability to interconnect the world in an extraordinary way. The IoT has grown immensely over the years, and found applications in transportation, infrastructures, agriculture, healthcare, and manufacturing [16, 17]. Queueing theory has emerged as a viable alternative in modeling various facets of IoT networks [18–22].

2. POISSON PROCESS

A random process $\{A(t)|t \geq 0\}$ taking nonnegative integer values is a Poisson process with rate λ given that [23]
1. $A(t)$ is a counting process [24] that gives the number of arrivals that have taken place between 0 and time t, that is, for $A(0) = 0$ and for $s < t, A(t) - A(s)$ is the number of arrivals during the interval $(s, t]$.

2. The number of arrivals that take place during disjoint time intervals are independent.

3. The number of arrivals in any interval of length τ is characterized by the Poisson distribution with parameter $\lambda\tau$, that for all $t, \tau > 0$ and $n = 0,1, ...$ is given by

$$P[A(t + \tau) - A(t) = n] = e^{-\lambda\tau}\frac{(\lambda\tau)^n}{n!} \cdot \qquad (1)$$

Given a Poisson process, we consider that the interarrival times are independent and exponentially distributed with parameter λ. The exponential probability density function is specified by $p(\tau) = \lambda e^{-\lambda\tau}$. It follows that, $P[\tau < s] = 1 - e^{-\lambda s}$ and $P[\tau > s] = e^{-\lambda s}$ for $s \geq 0$.

For $t \geq 0$ and $\delta \geq 0$, we have that the probability that there are no arrivals during the small interval δ is given by $P[A(t + \delta) - A(t) = 0] = 1 - \lambda\delta + o(\delta)$, the probability that there is one arrival during the small interval δ is given by $P[A(t + \delta) - A(t) = 1] = \lambda\delta + o(\delta)$, and the probability that there are two or more arrivals during the small interval δ is given by $P[A(t + \delta) - A(t) \geq 2] = o(\delta)$, where $o(\delta)$ is a function of δ such that $\lim_{\delta \to 0} \frac{o(\delta)}{\delta} = 0$.

If multiple independent Poisson processes $A_1, \ldots, A_k$ are merged into a single process as a sum $A = A_1 + \cdots + A_k$, this process is also Poisson with a rate given by the sum of the rates of the component Poisson processes [23].

3. THE M/M/*m* QUEUE

The M/M/*m* queue has m servers [23]. A customer at the beginning of the queue is routed to any server that is available at that moment. The state transition diagram is shown in Figure 1.

We can write down the steady state probabilities p_k and take $\delta \to 0$, to have [23]

$$\lambda p_{k-1} = k\,\mu\,p_k, \qquad k \leq m, \tag{2}$$

$$\lambda p_{k-1} = m\,\mu\,p_k, \qquad k > m.$$

From these equations, we can obtain [23]

$$p_k = \begin{cases} p_0 \dfrac{(m\rho)^k}{k!}, & k \leq m, \\[2mm] p_0 \dfrac{m^m \rho^k}{m!}, & k > m, \end{cases} \tag{3}$$

where ρ, the utilization factor, is given by

$$\rho = \frac{\lambda}{m\mu} < 1. \tag{4}$$

From the equations above we can calculate p_0 with the condition, $\sum_{k=0}^{\infty} p_k = 1$, we have that
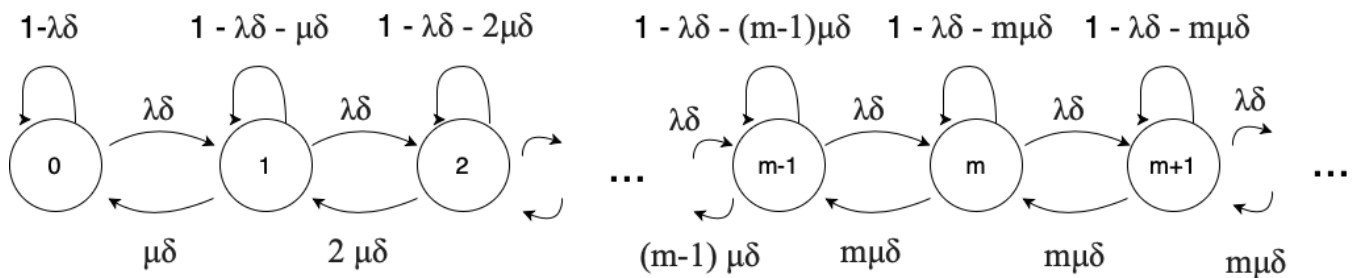

Figure 1. State transition diagram of the M/M/*m* queue.

$$p_0 = \left[1 + \sum_{k=1}^{m-1} \frac{(m\rho)^k}{k!} + \sum_{k=m}^{\infty} \frac{(m\rho)^k}{k!} \frac{1}{m^{k-m}}\right]^{-1} \tag{5}$$

and from there, we get [23]

$$p_0 = \frac{1}{\sum_{k=0}^{m-1} \frac{(m\rho)^k}{k!} + \frac{(m\rho)^m}{m!(1-\rho)}} \cdot \tag{6}$$

4. MARKOVIAN QUEUEING NETWORKS

The focus is on a N node open Markovian network. The network is open in the sense that it permits external arrivals and departures. The external arrivals at the ith node are generated by a Poisson source at an average rate of γ_i customers per second. The ith node consists of a single queue with, say, m_i servers with an exponentially distributed service time. After the customer completes service at the ith node it proceeds to the jth node with probability r_{ij} where it represents an internal arrival to the jth node. Note that it is possible for the customer to leave the network with a probability $1 - \sum_{j=1}^{N} r_{ij}$. The model also allows feedback to nodes that have been already visited. The total arrival rate at the ith node which can be comprised of both external and internal arrivals is denoted by λ_i customers per second. It is therefore given by [23]

$$\lambda_i = \gamma_i + \sum_{j=1}^{N} \lambda_j r_{ji} \tag{7}$$

It follows as a result of Jackson's theorem that for such a network each node behaves as if the input is Poisson. This is so even though the arrival processes at different nodes are not necessarily Poisson. Therefore if $p(k_1, k_2, \ldots, k_N)$ denotes the equilibrium probability that there are k_i customers in the 1st node, k_2 customers in the 2nd node and so on, k_N customers in the Nth node then as a result of Jackson's theorem the joint probability can be represented as a product of the marginal probabilities $p_i(k_i)$ for $i = 1, 2, \ldots, N$, that is [23]

$$p(k_1, k_2, \ldots, k_N) = p_1(k_1) p_2(k_2) \cdots p_N(k_N) \tag{8}$$

where $p_i(k_i)$ is the solution for the equilibrium probability of finding k_i customers in the queue of the ith node as if it is an isolated queue operating by itself with an input arrival rate λ_i for $i = 1, 2, \ldots, N$. In other words, the product form of the joint probability reveals the independence as indicated by the amazing result of the Jackson's theorem.

5. MODELING NETWORKS OF QUEUES

An example of an open Markovian network with $N = 4$ nodes is illustrated in Figure 2.
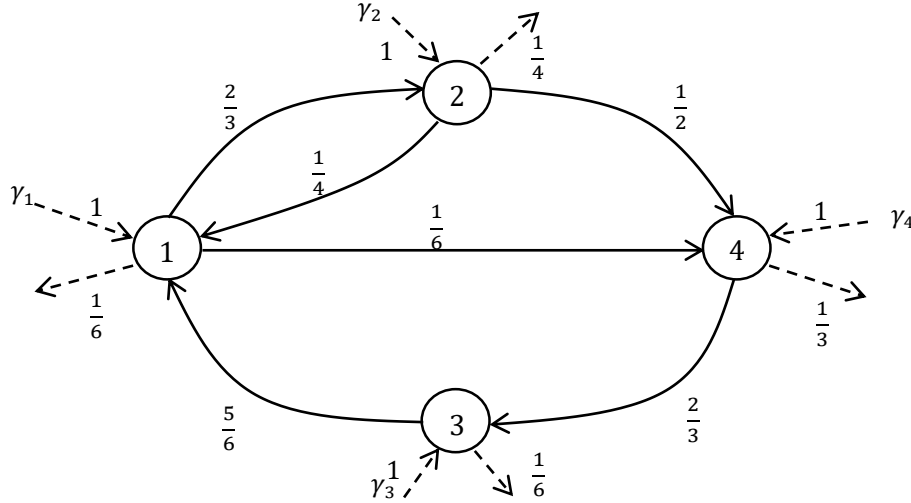
Figure 2. Example of an open network.

The branch labels are r_{ij}. These transition probabilities comprise the $N \times N$ matrix $\boldsymbol{R} = [r_{ij}]$. In the case of the example open network given in Figure 2, the matrix $\boldsymbol{R}$ is given by

$$\boldsymbol{R} = \begin{bmatrix} 0 & 2/3 & 0 & 1/6 \\ 1/4 & 0 & 0 & 1/2 \\ 5/6 & 0 & 0 & 0 \\ 0 & 0 & 2/3 & 0 \end{bmatrix} \tag{9}$$

In order to determine the arrival rate to the ith node λ_i, we need to solve $\lambda_i = \gamma_i + \sum_{j=1}^{N} \lambda_j r_{ji}$ for $i = 1,2,\dots,N$. Let $\boldsymbol{\lambda} = [\lambda_1, \lambda_2, \dots, \lambda_N]$ and $\boldsymbol{\gamma} = [\gamma_1, \gamma_2, \dots, \gamma_N]$. The equation can then be rewritten as

$$\boldsymbol{\lambda} = \boldsymbol{\gamma} + \boldsymbol{\lambda R} \tag{10}$$

It follows that in order to find the arrival rates $\boldsymbol{\lambda}$, we need to evaluate

$$\boldsymbol{\lambda} = \boldsymbol{\gamma}(\boldsymbol{I} - \boldsymbol{R})^{-1} \tag{11}$$

where $\boldsymbol{I}$ denotes the identity matrix given by

$$\boldsymbol{I} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{12}$$

Note that $\det(\boldsymbol{I} - \boldsymbol{R}) \neq 0$ for the matrix $(\boldsymbol{I} - \boldsymbol{R})$ to be invertible [25].

6. NUMERICAL EXAMPLES

The random input vector is binary, that is, $\gamma_i = 0$ or $\gamma_i = 1$ for $i = 1, \dots, 4$.

The determinant of the matrix $I - R$ is

$$\det(I - R) = 0.5556 \tag{13}$$

Note that $\det(I - R) \neq 0$. Therefore the matrix $I - R$ is invertible and the inverse matrix $(I - R)^{-1}$ is

$$(I - R)^{-1} = \begin{bmatrix} 1.8 & 1.2 & 0.6 & 0.9 \\ 0.95 & 1.63 & 0.65 & 0.97 \\ 1.5 & 1 & 1.5 & 0.75 \\ 1 & 0.67 & 1 & 1.5 \end{bmatrix} \tag{14}$$

Therefore, the vector of arrival rates can be readily evaluated as $\lambda = \gamma(I - R)^{-1}$. Note that the numerical example is implemented in MATLAB [26, 27].

The arrival rates for each of the nodes of the example open network are presented in Figure 3. It can be readily observed that for the considered time range the arrival rates are $\lambda_1 \lesssim 5.75$ packets per second at the 1st node in the network, $\lambda_2 \lesssim 5$ packets per second at the 2nd node in the network, $\lambda_3 \lesssim 4.25$ packets per second at the 3rd node in the network, and $\lambda_4 \lesssim 3.5$ packets per second at the 4th node in the network.
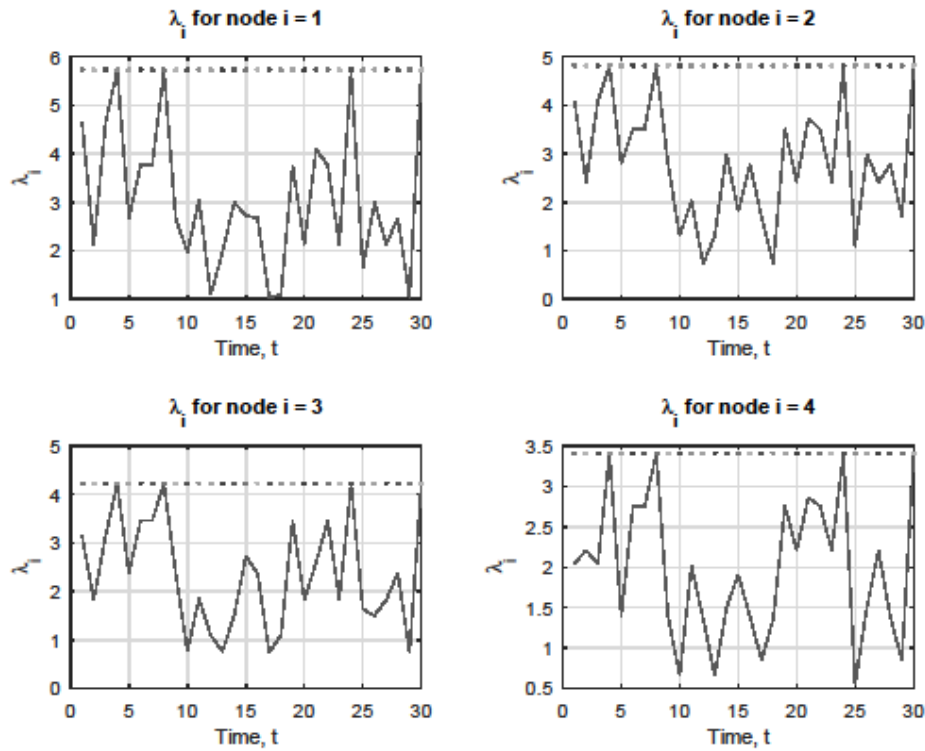
Figure 3. Arrival rates for each of the nodes in the open network.

7. CONCLUSION

The paper focused on the modeling of networks of queues with memoryless queues considered at each node in the network. The network was open in the sense that it permitted external arrivals and departures. The model was developed in MATLAB. It was illustrated through an example of a simple network where the network was modeled as a matrix. Arrival rates for all nodes in the network could then be obtained based on matrix calculations.

REFERENCES

1. Tanenbaum, A. S. and Wetherall, D. (2010). Computer Networks, Pearson.
2. Kurose, J. and Ross, K. (2016). Computer Networking: A Top-Down Approach, Pearson.
3. Peterson, L. L. and Davie, B. S. (2011). Computer Networks: A Systems Approach, Morgan Kaufmann.
4. Stallings, W. (2013). Data and Computer Communications, Pearson.
5. Leon-Garcia, A. and Widjaja, I. (2003). Communication Networks: Fundamental Concepts and Key Architectures, McGraw-Hill.
6. Walrand, J. and Parekh, S. (2018). Communication Networks: A Concise Introduction, Morgan and Claypool Publishers.
7. Kumar, M. B. D. and Deepa, B. (2015). Computer Networking: A Survey, *International Journal of Trend in Research and Development*, vol. 2, no. 5, pp. 126-130.
8. Slone, J. P. (1999). Local Area Network Handbook, Auerbach Publications.
9. Conti, M. *et al*. (1997). Metropolitan Area Networks, Springer.
10. Reed, K. D. (2004) Introduction to Wide Area Networks: Protocols and Applications for Network to Network Connectivity, Westnet Learning.
11. Beard, C. and Stallings, W. (2015). Wireless Communication Networks and Systems, Pearson.
12. Howser, G. (2020). Computer Networks and the Internet: A Hands-On Approach, Springer.
13. Comer, D. E. (2013). Internetworking with TCP/IP: Principles, Protocols, and Architecture, Pearson.
14. Matthews, J. (2005). Computer Networking: Internet Protocols in Action, Wiley.
15. McCullough, B. (2018). How the Internet Happened: From Netscape to the iPhone, Liveright.
16. Cirani, S. et al. (2018). Internet of Things: Architectures, Protocols, and Standards, Wiley.
17. Greengard, S. (2015). The Internet of Things, The MIT Press.
18. Al-Shammari, H. Q. et al. (2020). Service Embedding in IoT Networks, *IEEE Access*, vol. 8, pp. 2928-2962.
19. Sufyan, F. et al. (2020). Computation Offloading for Distributed Mobile Edge Computing Network: A Multiobjective Approach, *IEEE Access*, vol. 8, pp. 149915-149930.
20. Leite, J. R. E. et al. (2019). A Validation Method for AdHoc Network Simulation Including MANETs, VANETs and Emergency Scenarios, AdHoc Networks and Wireless (AdHoc-Now), Lecture Notes in Computer Science, vol. 11803, p. 32-47, Springer.
21. Leite, J. R. E. et al. (2017). Simulation of AdHoc Networks Including Clustering and Mobility, AdHoc Networks and Wireless (AdHoc-Now), Messina, Italy. Lecture Notes in Computer Science, vol. 10527, pp. 199-209, Springer.
22. Althoubi, A. et al. (2021). Delay Analysis in IoT Sensor Networks, *Sensors*, no. 11: 3876, MDPI.
23. Bertsekas D. P. and Gallager, R. G. (1992). Data Networks, Pearson.
24. Gallager, R. G. (1995). Discrete Stochastic Processes, Kluwer Academic Publishers.
25. Strang, G. (2016). Introduction to Linear Algebra, Wellesley-Cambridge Press.
26. A. Gilat, "MATLAB: An Introduction With Applications," Wiley, 2016.
27. H. Moore, "MATLAB for Engineers," Pearson, 2017.

PRELIMINARY SCREENING OF PROBIOTICS CHARACTERISTICS OF BACTERIA ISOLATED FROM DIFFERENT KIND OF DOMESTIC CHEESE

Natalija Atanasova-Pancevska[1], Dzoko Kungulovski[2]

[1]natalijaap@gmail.com, [2]dzokok@yahoo.com

[1,2] Department of Microbiology and Microbial Biotechnology, Institute of Biology, Faculty of Natural Sciences and Mathematics, "Ss. Cyril and Methodius" University, Skopje, North Macedonia

Abstract. *Probiotics are beneficial bacteria that contribute to the health and balance of the intestinal tract. In people, the most common way to prevent from getting any infectious disease or digestive upset is by using vaccines and antibiotics. Besides that, naturally occurring microflora is a good alternative to protect the host gut. In developing a good strain of probiotics, there are a few criteria to be achieved by the bacteria such as ability to tolerate acidic condition and survival in the presence of bile salts. All isolates were grown 24 hours in Man Rogosa and Sharp (MRS). Acid tolerance test was done by incubating the isolates into Phosphate Buffered Saline (PBS) in pH 2, and 3 for 3 hours. For the bile salts test, the isolates were exposed to the bile salts for 4 hours. At each hour, the optical density (OD) of the isolates was measured. For both test, the cells survival in these two conditions was measured by OD after incubation on new fresh MRS. From 12 isolates, 6 isolates are acid tolerate while 5 isolates are able to survive in presence of bile salts. For this preliminary screening, 4 isolates were selected for further works on probiotics characteristics.*

Keywords*: probiotics; protection; beneficial; screening.*

1.INTRODUCTION

Probiotics are known as one of the most beneficial microbial feed supplement to the animal. It is significant to the animal host in improving their gastrointestinal health by accelerating the production of the beneficial microflora, enhancing the host resistance from pathogenic and toxic microorganisms as well as increasing the level of immunomodulatory of the host (Mourad and Nour-Eddine, 2006).

Many beneficial effects of these microorganisms including anti-inflammatory properties, modulation of host's immune responses, reduction of lactose intolerance as well as inhibition of pathogenic bacteria have been described (De Vrese and Schrezenmeir, 2008; Leahy et al., 2005). A suitable probiotics strain must tolerate acidic pH of stomach and bile salts of intestinal tract and be able to adhere to mucosal surfaces (Shobharani and Agrawal, 2011).

Traditionally, probiotics have been utilised in dairy products such as milk or yoghurt and it has been hypothesized that milk enhances probiotic efficacy by providing lactose as a substrate (Varcoe et al., 2002). At the present, a large number of dairy products are present on the market and are being promoted with health claims based on several characteristics of selected strains of lactic acid bacteria, particularly belonging to the genera Lactobacillus and Bifidobacterium (Shah, 2000).

Microorganisms ingested with food begin their journey to the lower intestinal tract via the mouth and are exposed during their transit through the gastrointestinal tract to successive stress factors that influence their survival (Marteau et al., 1993; Simon and Gorbach, 1987). The time reported from entrance to release from the stomach is about 90 min (Berrada et al., 1991), but further digestive processes have longer residence times. Cellular stress begins in the stomach, which has pH as low as 1.5 (Lankaputhra and Shah, 1995). Bile secreted in the small intestine reduces the survival of bacteria by destroying their cell membranes, whose major components are lipids and fatty acids and these modifications may affect not only the cell permeability and viability, but also the interactions between the membrane and the environment (Gilliland, 1987; Gilliland et al., 1984). Therefore before a probiotics can benefit human health it must fulfil several criteria such as the ability to tolerate acid and bile salts as well as to grow in the lower intestinal tract (Zhu et al., 2000; Pereira and Gibson, 2002; Ouwehand et al., 2002; Hirayama and Rafter, 2000). So, the first tool in the selection of a strain of probiotics interest is represented by in vitro methods aiming to ascertain the ability to survive passage through the upper gastro-intestinal tract and arrive alive at its site of action.

In order to develop the probiotics as a feed supplement, a preliminary screening on the characteristics of the strain is important to determine its ability to survive in the gastrointestinal tract condition. The preliminary screening was done to select the best strain that could survive in acidic condition as well as in the presence of bile salts.

2. MATERIALS AND METHODS

2.1. Cheese collection

Three traditional cheese samples (~200 g) were collected from three traditional Macedonian families who produce cheese in domestic conditions. The samples were aseptically transferred to the Microbiological Lab, Department of Microbiology and Microbial Biotechnology, at theFaculty of Natural Sciences and Mathematics, "Ss. Cyril and Methodius" University, Skopje, North Macedonia, under cold and aseptic conditions.

2.2. Isolation of beneficial microbes

An amount of 25 g of each cheese sample was added to 225 ml 0.1% w/v peptone water and homogenized at 280 rpm for three min. The cheese suspension was diluted in 2% w/v sodium citrate and cultured on two De Man, Rogosa and Sharpe (MRS) agar plates and incubated under anaerobic conditions for 2 days at 37°C. The 3–4 different single colonies were randomly selected from each cultured plate. The selected colonies were Gram stained, examined microscopically, and catalase test was also performed. Gram-positive and catalase-negative bacilli were chosen and stored in cryotube containing 15% (v/v) glycerol at −20°C for further characterization.

2.3. Acid and bile tolerance

Tolerance to acid was determined according to the method described at Yu et al. (2013), as the following: isolated strains were grown in MRS broth at 37ºC for 24-48 h, and sub-cultured in fresh MRS broth adjusted to pH 2.0 and 3.0 with hydrochloric acid (3.0 mol/L). The initial bacterial concentration was adjusted to 10^9 CFU/mL and the survival rate was determined after incubation for 180 min at pH 2.0 and pH 3.0 which reflects the time spent by food in the stomach (Maragkoudakis et al., 2006). Survival rate was determined using plating on MRS agar and calculating viable counts at different intervals.
Bile tolerance test was conducted using the method described by Gilliland et al. (1984). Overnight cultures of the isolated strains with initial concentration of 10^9 CFU/mL were inoculated into MRS broth containing 0.5, 1.0 and 2.0 % (w/v) bile. Survival rate of the isolates were measured following 24 h incubation at 37°C using the method described for acid tolerance assay.

2.4. Antibiotic susceptibility

Susceptibility of the isolated strains to the antibiotics commonly used by human was evaluated according to the method described at Le Blanc et al. (2010). Briefly, the cultures were overlaid on Muller-Hinton agar plate and antibiotic discs were placed on it and incubated 24 h at 37°C. The assay was performed in triplicates and mean diameter of inhibition zones around antibiotic discs were recorded. The susceptibility was expressed in terms of resistance (R), intermediate susceptibility (I), and susceptibility (S) based on data from the National Committee for Clinical Laboratory Standards (NCCLS).

2.5. Haemolytic activity

In order to evaluate hemolytic activity of the isolates, fresh bacterial cultures were plated on Blood Agar plate containing 5% v/v horse blood. The plates were examined for signs of β- hemolysis (clear zones around colonies), α-hemolysis (green-hued zones around colonies) or γ- hemolysis (no zones around colonies) following 24-48 h incubation at 37°C (Zoumpopoulou et al., 2008).

2.6. Antimicrobial activity against Gram negative pathogen

Antimicrobial activity of the isolated strains against *S. enterica* serovar Typhimurium ATCC 14028 was investigated using the method described by Yu et al. (2013) and Ebrahimi et al. (2013). A fresh culture of the isolated bacterium, grown in MRS broth, was centrifuged (6000 g, 10 min, 4°C) and the resulting supernatant was adjusted to pH 6.5 with NaOH (1 M) in order to rule out acid inhibition. The supernatant was used to determine antibacterial activity of the isolated strain against *S. typhiurium* using well diffusion assay. This assay was performed in triplicates and mean diameter of inhibition halos were measured.

3. RESULTS AND DISCUSSION

3.1. Isolation and identification of potent probiotic strain

Twelve bacterial strains were isolated from three traditional cheese samples from N. Macedonia. Further studies were based on the morphology, Gram staining, Catalase production and motility tests. They were Gram positive, Catalase negative, non motile rods and were regarded for further characterized as potent probiotic strains.
 The growth was observed at 10, 37 and 45ºC but the strains did not tolerate 55 ºC. In addition, the culture grew well in the media containing 2.5, 6.5 and 10% salt but generally did not grow in the medium containing 18% NaCl. Tables 1 and 2 displays results from these tests.

Table 1. Morphological and physiological characterization of the isolates.

Isolate No.	growth on MRS agar	morphology	Gram staining	catalase test	motility test
Isolate No.1	+	rods	+	-	-
Isolate No.2	+	rods	+	-	-
Isolate No.3	+	rods	+	-	-
Isolate No.4	+	rods	+	-	-
Isolate No.5	+	rods	+	-	-
Isolate No.6	+	rods	+	-	-
Isolate No.7	+	rods	+	-	-
Isolate No.8	+	rods	+	-	-
Isolate No.9	+	rods	+	-	-
Isolate No.10	+	rods	+	-	-
Isolate No.11	+	rods	+	-	-
Isolate No.12	+	rods	+	-	-

According to Peterson et al. (1990) and Salminen et al. (1996) only few microorganisms survive in cheeses because of its low redox, low pH and high salt. In our research only three isolates were grown on 18% salt in the medium, but all tested isolates grown on 2.5, 6.5 and 10% of salt.

Table 2. The tolerance of isolated strains of different incubation temperature and concentration of salt in medium.

Isolate No.	incubation temperature (ºC)				concentration of salt (%)			
	10	37	45	55	2.5	6.5	10	18
Isolate No.1	+	+	+	-	+	+	+	-
Isolate No.2	+	+	+	-	+	+	+	-
Isolate No.3	+	+	+	-	+	+	+	-

Isolate No.4	+	+	+	+	+	+	+	-
Isolate No.5	+	+	+	-	+	+	+	-
Isolate No.6	+	+	+	-	+	+	+	-
Isolate No.7	+	+	+	-	+	+	+	-
Isolate No.8	+	+	+	-	+	+	+	+
Isolate No.9	+	+	+	+	+	+	+	-
Isolate No.10	+	+	+	-	+	+	+	-
Isolate No.11	+	+	+	-	+	+	+	+
Isolate No.12	+	+	+	+	+	+	+	+

3.2. Acid and bile tolerance

From twelve isolates, six isolates are acid tolerate (for pH 2, and pH 3) while others did not grow on acidic medium. Acid tolerance assay showed that only isolates No. 1, 3, 5, 7 and 9 can tolerate both pH, whith survival percentage between 58 and 80% (for pH 2) and survival rate beween 65 and 85% (for pH 3).

Bacterial isolates were treated with different concentrations of bile salts. According to the results, from tested isolates five strains are able to survive in presence of bile salts. The results showed decrease in viability by increasing bile concentration.

Table 3. Results from acid tolerance test, bile tolerance test, antimicrobial activity test and haemolysis test.

Isolate No.	Acid tolerance test		Bile tolerance test			Antimicrobial activity test ZI (mm)	Haemolyis test
	pH 2	pH 3	0.5%	1%	2%		
Isolate No.1	+	+	+	+	+	+ (5 mm)	γ (no haemolysis)
Isolate No.2	-	-	-	-	-	-	α
Isolate No.3	+	+	+	+	+	+ (7 mm)	γ (no haemolysis)
Isolate No.4	+	-	-	-	-	-	α
Isolate No.5	+	+	+	+	+	+ (10 mm)	γ (no haemolysis)
Isolate No.6	-	-	-	-	-	-	β
Isolate No.7	+	+	+	+	+	+ (11 mm)	γ (no haemolysis)
Isolate No.8	-	-	+	+	+	+ (2 mm)	β
Isolate No.9	+	+	-	-	-	-	β
Isolate No.10	-	+	-	-	-	-	β
Isolate No.11	-	-	-	-	-	-	α
Isolate No.12	-	-	-	-	-	-	α

For a probiotics strain, survival under gastrointestinal environment condition is important criteria to be fulfilled which depends on tolerance to low pH and high bile concentration as well as resistance to antibiotics and antimicrobial activity against gram negative pathogens, such as *S. typhimurium*. Also, tolerance to extremely acidic condition is an important feature of a probiotics strain (Guo et al., 2009).

Our tested isolates from domestic Macedonian cheese showed good tolerance to low pH showing its ability to survive under acidic environment of stomach. These strains were more tolerant to low pH in comparison with the *L. plantarum* studied by Lotfi et al. (2010) who isolated LAB from traditional cheese from Heris and Sarab regions.

The physiological concentration of bile in the small intestine has been reported to be between 0.2 and 2.0% (Gunn, 2000).Our isolates from this study showed a good tolerance to higher bile salts concentrations. Also, the good bile tolerance of the isolated LAB strains has been reported previously at García-Ruiz et al. (2014). Similar results were

also reported by Mourad and Nour-Eddine (2006) who found that one of their isolates showed 65% survival rate following exposure to 2.0% bile. Resistance to bile salts varies a lot among lactic acid bacteria species and even between strains themselves. Bile resistance of some strains is related to the specific enzymatic activity of Bile Salt Hydrolase (BSH) which helps hydrolyzing conjugated bile, thus reducing its toxic effect (Du Toit et al., 1998).

3.3. Antimicrobial activity against Gram negative pathogen

Antibacterial activity is an important feature of the probiotics strains. The isolates were checked for their antibacterial activity against main gastrointestinal pathogen *S. typhimurium*. Our results showed that five isolates inhibit indicator pathogen bacteria with different inhibition level. Isolate No.8 was weakly effective against *S. typhimurium* with inhibition zone diameter of 2 mm, isolate No.1 was slightly more effective against *S. typhimurium* with inhibition zone diameter of 5 mm, whereas other three isolates (No. 3, 5 and 7) showed stronger antibacterial activity against tested Gram negative pathogen, with inhibition zone diameter of 7 (isolate No. 3), 10 (isolate No. 5) and 11 mm (isolate No. 7).

Antimicrobial activity of LAB against potential pathogens has been reported by Yu et al. (2013), while some studies did not show effective antibacterial activity of tested LAB strains against pathogenic bacteria (Maragkoudakis et al., 2006). This property of the isolated bacterium can be used in prophylactic or therapeutic usage. The inhibitory activity of the LAB strains might be due to either production of organic acids or bacteriocines (Yu et al., 2013).

3.4. Haemolytic activity

Absence of hemolytic activity is another considered safety prerequisite for the selection of a probiotics strain. Hemolysis is the break down of the membrane of red blood cells by a bacterial protein known as hemolysin, which causes the release of hemoglobin from the red blood cell.

The hemolytic activity of isolates was determined by using Blood agar containing 5% (w/v) horse blood and the plates were incubated at 37 °C for 48 h. After incubation, the hemolytic activity of isolated strains was evaluated and classified on the basis of lysis of red blood cells in the medium around the colonies. The green zones around colonies (α-hemolysis), clear zones around colonies (β-hemolysis) and no zones around colonies (γ-hemolysis) on Blood agar plates. Only strains with γ-hemolysis are considered as safe (Mangia e al., 2019).

Four of the tested strains showed α-hemolytic acivity, the other four isolates were with β-hemolytic activity when grown on Blood agar plates. Only isolates No. 1, 3, 5 and 7 showed γ hemolytic, i.e., negative, or no hemolytic activity. These results confirm their safety as potent probiotics strains.

3.5. Antibiotic susceptibility test

Frequent antibiotic administration causes gut microbiota imbalance and an increased susceptibility to infection was caused by opportunistic microorganisms (Willing et al., 2011). Probiotics strains which are resistant to antibiotics can proliferate in gut and maintain microbial balance and reduce opportunistic microorganisms (Le Blanc et al., 2010).

The antibiotic susceptibility of isolates was tested against selected antibiotics (erythromycin, streptomycin, kanamycin, vancomycin, penicillin, gentamicin and polymyxin B) commonly used by human, by using antibiotic disc diffusion method on Muller-Hinton agar plates. Antibiotic discs were placed on inoculated and solidified Muller-Hinton agar platea and give them 30 min for antibiotic diffusion and after that incubated (37 °C for 48 h). The zone of inhibition was measured for each antibiotic disc after the completion of incubation. The susceptibility was expressed in terms of resistance (R), intermediate susceptibility (I), and susceptibility (S) based on data from the National Committee for Clinical Laboratory Standards (NCCLS). The test was performed only with isolates No. 1, 3, 5 and 7, which were with γ hemolytic activity on previous test.

Table 4. Susceptibility of the isolated strains to different antibiotics.

antibiotics	concentration	zone of inhibition (mm)				susceptibility			
		No1	No3	No5	No7	No1	No3	No5	No7
erythromycin	15 μg	20	20	11	9	I	I	R	R
streptomycin	10 μg	15	21	5	6	S	S	R	R
kanamycin	30 μg	11	16	18	9	R	I	I	R
vancomycin	30 μg	13	10	15	16	R	R	R	R
penicillin	10 IU	29	34	20	18	S	S	I	I
gentamicin	10 μg	14	19	19	13	I	S	S	I
polymyxin B	300 IU	8	7	5	7	R	R	R	R
R= **R**esistance, **I**= **I**ntermediate susceptibility, **S**= **S**usceptibility									

From all four tested isolates, isolate No7 showed resistance to majority of antibiotics used in this study, including erythromycin, streptomycin, kanamycin, vancomycinand polymyxin B. In contrast, isolate No3 from our study was susceptible to penicillin, gentamicin as well as streptomycin. Table 4 compares antibiotic resistance of all four isolates.

Similar antibiotic resistance pattern of probiotic *L. plantarum* strains was reported by Yu et al. (2013). The ability of probiotics to resist antibiotics might be beneficial to people suffering from intestinal disorders due to improper administration of antibiotics (Salminen et al., 1998). However, it is important that the bacterial strains involved do not transfer antibiotic resistance genes from foods to intestinal microflora (Mathur and Singh, 2005).

4. CONCLUSIONS

In this study, macedonian domestic cheeses were examined to isolate potentially probiotics bacteria for the first time and a four strains with good probiotics properties were isolated. These isolates showed tolerance to high bile concentration, low pH and survived under condition simulating human gastrointestinal tract. Thus, it could be predicted that isolates would be able to pass stomach and reach intestine in adequate amounts. In addition, this strain displayed a good antibacterial activity against Gram negative food-borne pathogens *S. typhimurium*. Thus, these four isolates could be considered as a good probiotics candidate. However, further investigations including *in vivo* experiments as well as molecular analysis would be helpful to elucidate its potential health benefits and application as a probiotics strains in the dairy industry.

REFERENCES

4. Mourad K., Nour-Eddine K. 2006, *In vitro preselection criteria for probiotic Lactobacillus plantarum strains of fermented olives origin.* International Journal of Probiotics and Prebiotics, 1 (1), pp. 27- 32.
5. De Vrese M., Schrezenmeir J. 2008, *Probiotics, prebiotics, and synbiotics.* Book section In: Food Biotechnology. Advances in Biochemical Engineering/Biotechnology, vol. 111. Berlin: Stahl, U., Donalies, U. E. B., Nevoigt, E. (Eds.); Springer- Verlag, pp. 1-66.
6. Leahy SC., Higgins DG., Fitzgerald GF., Van Sinderen D., 2005, *Getting better with Bifidobacteria*. Journal of Applied Microbiology 98 (6), pp. 1303- 15.
3. Shobharani P., Agrawal R., 2011, *A Potent Probiotic Strain from Cheddar Cheese.* Indian Journal of Microbiology 51(3), pp. 251- 258.
4. Le Blanc A M., Castillo NA., Perdigon G., 2010, *Anti-infective mechanisms induced by a probiotic Lactobacillus strain against Salmonella enterica serovar Typhimurium infection.* International Journal of Food Microbiology 138 (3), pp. 223- 231.
5. Yu Z., Zhang X., Li S., Li C., Li D., Yang Z., 2013, *Evaluation of probiotic properties of Lactobacillus plantarum strains isolated from Chinese sauerkraut.* World Journal of Microbial Biotechnology 29 (3), pp. 489- 498.
6. Maragkoudakis PA., Zoumpopouloua G., Miarisa C., Kalantzopoulosa G., Potb B., Tsakalidou E., 2006, *Probiotic potential of Lactobacillus strains isolated from dairy products.* International Dairy Journal 16 (3), pp. 189- 199.
7. Gilliland SE., Staley TE., Bush LJ., 1984, *Importance in bile tolerance of Lactobacillus acidophilus used as a dietary adjunct.* Journal of Dairy Science, 67 (12), pp. 3045- 3051.

8. Zoumpopoulou G., Foligne B., Christodoulou K., Grangette C., Pot B., Tsakalidou E., 2008, *Lactobacillus fermentum ACA-DC 179 displays probiotic potential in vitro and protects against trinitrobenzene sulfonic acid (TNBS)-induced colitis and Salmonella infection in murine models.* International Journal of Food Microbiology 121 (1), pp. 18- 26.

9. Ebrahimi Alavijeh S., Mahzounieh M., Mobini Dehkordi M., 2013, *Effects of metabolites of Lactobacilli isolated from local yoghurts in Chahrmahal va Bakhtiary on pathogenic bacteria.* Biological Journal of Microorganism 2 (5), pp. 11- 20.

10. Varcoe, J., Zook, C., Sui, J., Leighton, S., Busta, F. and Brady, L., 2002, *Variable response to exogenous Lactobacillus acidophilus NCFM_ consumed in different delivery vehicles.* J. Appl. Microbiol. 93, pp. 900–906.

11. Shah, N.P., 2000, *Probiotic bacteria: selective enumeration and survival in dairy foods.* J. Dairy Sci. 83, pp. 894–907.

12. Marteau, P., Pochart, P., Bouhnik, Y. and Rambaud, J.C., 1993, *Fate and effects of some transiting microorganisms in the human gastrointestinal tract.* World Rev. Nutr. Diet. 74, pp. 1.

13. Simon, G.L., Gorbach, L., 1987, *Intestinal flora and gastrointestinal function.* In: Physiology of the Gastrointestinal Tract, (Johnson, L.R., Ed.), vol. 2, p. 1729. Raven Press, New York, NY.

14. Berrada, N., Lemeland, J.F., Laroch, G., Thouvenot, P., Piaia, M., 1991, *Bifidobacterium from fermented milks: survival during gastric transit.* J. Dairy Sci. 74, pp. 409–413.

15. Lankaputhra, W.E.V., Shah, N.P., 1995, *Survival of Lactobacillus acidophilus and Bifidobacterium spp in the presence of acid and bile salts.* Cult. Dairy Prod. J. 30, pp. 2–7.

16. Gilliland, S.E., 1987, *Importance of bile tolerance in lactobacilli used as dietary adjunct.* In: Biotechnology in the Feed Industry, (Lyons, T.P., Ed.), p. 149–155. Alltech Feed Co., Lexington, KY.

17. Gilliland, S.E., Stanley, T.E., Bush, L.J., 1984, *Importance of bile tolerance of Lactobacillus acidophilus used as a dietary adjunct.* J. Dairy Sci. 67, pp. 3045–3051.

18. Zhu, W.M., Liu, W., Wu, D.Q., 2000, *Isolation and characterization of a new bacteriocin from Lactobacillus gasseri KT7.* J. Appl. Microbiol. 88, pp. 877–886.

19. Pereira, D.I., Gibson, G.R., 2002, *Effects of consumption of probiotics and prebiotics on serum lipid levels in humans.* Crit. Rev. Biochem. Mol. Biol. 37, pp. 259–281.

20. Ouwehand, A.C., Salminen, S., Isolauri, E., 2002, *Probiotics: an overview of beneficial effects.* Antonie Van Leeuwenhoek 82, pp. 279–289.

21. Hirayama, K., Rafter, J., 2000, *The role of probiotic bacteria in cancer prevention.* Microbes Infect. 2, pp. 681–686.

22. Saarela, M., Mogensen, G., Fondern, R., MaËttoË , J., Mattila- Sandholm, T., 2000, *Probiotic bacteria: safety, functional and technological properties.* J. Biotechnol. 84, pp. 197–215.

23. Mangia N.P., Saliba L., Deiana P., 2019, *Functional and safety characterization of autochthonous* Lactobacillus paracasei *FS103 isolated from sheep cheese and its survival in sheep and cow fermented milks during cold storage.* Ann. Microbiol. 69, pp. 161–170.

24. Peterson SD., Marshall RT., Heymann H., 1990, *Peptidase profiling of Lactobacilli associated with cheddar cheese and its application to identification and selection of strain of cheese ripening studies.* Journal of Dairy Science 73 (6), pp. 1454- 64.

25. Salminen S., Laino M., Von Wright A., Vuopio-Varkila J., Korhonon T., Mattila-Sandholm T., 1996, *Development of selection criteria for probiotic strains to assess their potential in functional foods: a Nordic and European approach.* Bioscience Microflora 15 (2), pp. 61–67.

26. Guo Z., Wang J., Yan L., Chen W., Liu X., Zhang H., 2009, *In vitro comparison of probiotic properties of Lactobacillus casei Zhang, a potential new probiotic, with selected probiotic strains.* LWT- Food Science and Technology, 42 (10), pp. 1640-1646.

27. Lotfi H., Hejazi MA., Maleki Zanjani B., Barzegari A., 2010, *Isolation, Biochemical and Molecular Identification of Potentiallly Probiotic Bacteria from Traditional Dairy Products from Heris and Sarab Regions.* Journal of Food Research, 20/3 (1), pp. 1- 17

28. Gunn JS., 2000, *Mechanisms of bacterial resistance and response to bile.* Microbes Infection, 2 (8), pp. 907-913.

29. García-Ruiz A., de Llano DG., Esteban-Fernández A., Requena T., Bartolomé B., Moreno-Arribas MV., 2014, *Assessment of probiotic properties in lactic acid bacteria isolated from wine.* Food microbiology, 44, pp. 220- 225.

30. Mourad K, Nour-Eddin K., 2006, *In Vitro preselection criteria for probiotic Lactobacillus plantrum strains of fermented olives origin.* International Journal of Probiotics and Prebiotics, 1 (1), pp. 27- 32.

31. Du Toit M., Franz C., Schillinger U., Warles B., Holzappfel W., 1998, *Characterization and selection of probiotic lactobacilli for a preliminary minipig-feeding trail and their effect on serum cholesterol level, faeces moisture contents.* International Journal of Food Microbiology, 40, pp. 93- 104**.**

32. Willing BP., Russell SL., Finlay BB., 2011, *Shifting the balance: antibiotic effects on host–microbiota mutualism.* Nature Reviews Microbiology, 9, pp. 233- 243.

33. Salminen S., Von Wright A., Morelli L., Marteau P., Brassart D., de Vos WM., 1998, *Demonstration of safety of probiotic: a review.* International Journal of Food Microbiology, 44 (1- 2), pp.96- 106.

34. Mathur S., Singh R., 2005, *Antibiotic resistance in food lactic acid bacteria-a review.* International Journal of Food Microbiology, 105 (3), pp. 281- 295.

35. Maragkoudakis PA., Zoumpopouloua G., Miarisa C., Kalantzopoulosa G., Potb B., Tsakalidou E., 2006, *Probiotic potential of Lactobacillus strains isolated from dairy products.* International Dairy Journal, 16 (3), pp. 189- 199.

INDEX