Quest Journals
Journal of Research in Business and Management
Volume 9 ~ Issue 5 (2021) pp: 07-15
ISSN(Online):2347-3002
www.questjournals.org

Research Paper

The BIM Systems' Role in Architecture during Pandemics

Douaa Muthanna, Fulya Callialp
[1](*Electrical and Electronics Engineering Department, Marmara University Turkey)*
Corresponding Author: Fulya Callialp

ABSTRACT: *The Building Information Modelling (BIM) system is a collaborative tool between the design and construction processes in architectural practice. From infrastructure to typical commercial buildings or even small interior projects; this system allows to work collaboratively in-real time on the projects without causing delays and misinterpretations. This paper discusses how the BIM system works and its importance in the field with its current updates. In addition, the limitations will be illustrated before and during the BIM system to demonstrate the difficulties in a more comprehensive matter. Moreover, the future studies and a research of the development suggestions to overcome the difficulties that increases during the pandemic period will be reported besides a research of the development suggestions to overcome the difficulties that increas during the pandemic period.*

KEYWORDS: *BIM, Construction Management, Limitations, COVID-19, Virtual Reality, Game-Hybrid Systems, Remote Monitoring*

Received 26 April, 2021; Revised: 08 May, 2021; Accepted 10 May, 2021 © *The author(s) 2021. Published with open access at* www.questjournals.org

I. INTRODUCTION

COVID-19 had affected the lives tremendously with statistics of 49.7 million cases and more than million deaths globally. It is a fact that currently long lasting innovative solutions are needed in every aspect of lives. In the field of architecture and more particular in architectural project management, the Building Information Modelling (BIM) system is a well-established tool that has been used for quite a long time by engineers and architects to establish a well-maintained management system. BIM system is "a verb or adjective phrase to describe tools, processes and technologies that are facilitated by digital, machine-readable documentation about a building, its performance, its planning, its construction and later its operation". Coates [1] describes BIM as a set of interacting policies, processes and technologies producing a "methodology to manage the essential building design and project data in digital format throughout the building's life-cycle".

The BIM system is a very powerful tool in construction management field. The current difficulties depict that it might need to be tweaked or developed more to reach a higher level of effectiveness. Moreover, the industry experts are in need to develop their advanced technological skills to reach a level of project management that can assist in pandemics. For that reason, it becomes essential to analyze the current situation of the industry in terms of the usage of such powerful tool such as the BIM and how it can contribute in eliminating the effect of the virus within buildings. Especially, the construction industry has a major effect in controlling the spread of the virus. To indicate the latest development in the BIM technology is very important to state that the experts in the field can manage the BIM systems in project management on a more updated manner and eliminate virus spreading.

Regarding the development of the pandemic from June to November of 2020, the curves as predicted shows an alike pattern that had been seen in May. Table 1 and Table 2 demonstrate the status during that specific time in accordance to the data provided by the WHO on the 11th of November [2]. Cases on an international level had reached to be more that 45 million cases. As for the number of deaths it got up to 1 million case and more. Thus, within this pattern of affected cases and deaths building management had become a necessity in preventing the spreading of the virus especially large and complex buildings [2].

What made COVID-19 a highly risky pandemic is the fact that its differentiability from both quantitative and qualitative aspect from other types of disasters. The record of patients who lost their lives or considered to be an active case is higher than any pandemic that stroked the globe since the year of 1918 [3].

Table 1: Situation Report November, 2020-1 [2]

Location	Total Confirmed Cases	New Cases in the Last 7 Days	Total Deaths	New Deaths in the Last 7 Days
Globally	49,727,316	3,690,495	1,248,373	54,835
Americas	21,509,104	1,031,573	656,629	17,289
Europe	13,144,973	1,989,636	311,542	25,531
South-East Asia	9,641,945	390,157	149,326	5132
Eastern Mediterranean	3,307,411	214,072	84,305	5675
Africa	1,357,945	33,687	30,616	831
Western Pacific	765,197	31,370	15,942	377

Table 2: Situation Report November, 2020-2 [2]

Reporting Country	Total Confirmed Cases	New Cases in Last the 7 Days	Total Deaths	New Deaths in the Last 7 Days
Russian Federation	1,774,334	137,553	30,537	2302
France	1,714,361	382,553	39,849	551
Spain	1,328,832	95,732	38,833	2584
United Kingdom	1,171,445	159,781	48,888	2333
Italy	902,490	223,060	41,063	2445
Germany	658,505	125,575	11,289	808
Turkey	391,739	16,372	10,803	3376

COVID-19 is not following a typical pattern of a disaster but it has its own special pattern of cascade effect. Hence there are no accurate emergency scenarios that a system can follow but it's also considered a social catastrophe. It is also shown that the political management in many countries are fast and effective decision-making. All in all COVID-19 is affecting the globe. Researchers suggest that epidemic planning must be developed in terms methods, funds and planning [3]. New policies and regulations must be regularly updated to provide the most protection to people around the world.

II. BIM SYSTEM ROLE IN THE ARCHITECTURAL PROCESSES

Architecture is a business where it connects a clients and services. In other words, it is a service that provides information and site administration alongside with the other architectural duties. Such services are covered with a contractual agreement. Figure 1 depicts the activities that take place within the architectural processes in term of communication, construction and administration. The figure explains the core tasks that are done through the architectural project management and the supported data related in form of letters, emails, reports, certificates or hardcopy drawings. The purpose of these core elements is to be able to evaluate the effectiveness of the BIM system in these five key areas by measuring their contribution and obstacles.

The main processes of the architectural practice are given in Figure 2. Actually, various systems are an outcome from many different needs in the architectural companies such as ERP, PIM, CRM, QMS and KM, while the previous systems are seen to be of a digital nature the BIM system offers the chance and the ability to connect with those systems easily[1]. The BIM systems propose the idea business management that is against isolation of other systems that are used in the architectural companies and link data/information/knowledge and propose more fluent methods of automated data exchange in order to prevent data wastage. Such an approach intention is to benefit from the interaction of business organizations.

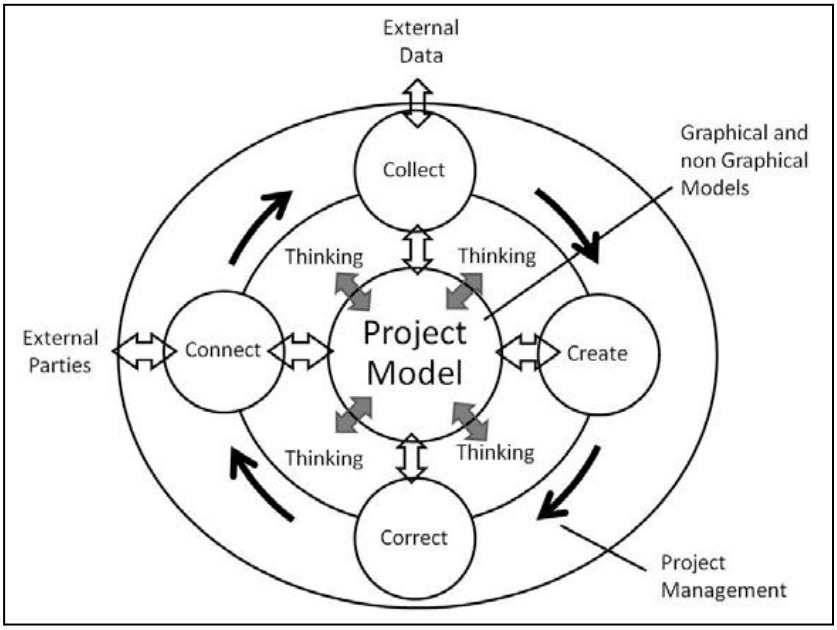

Figure 1: architectural processes chart [1]

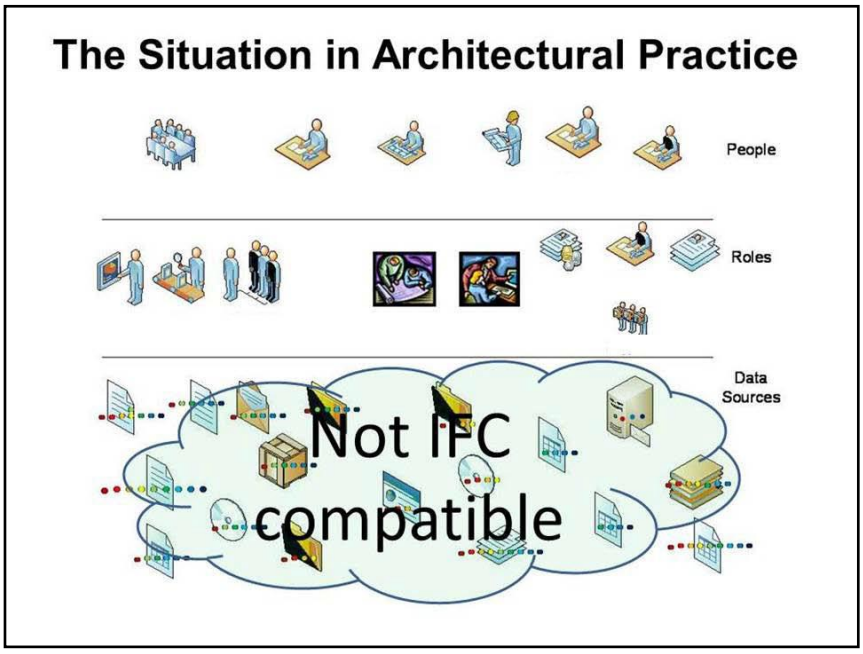

Figure 2: typical situation of data exchange in architectural firms

III. EFFECTS OF COVID-19 ON CONSTRUCTION METHOD

During the COVID-19 period many difficulties increased within a practice that is highly depending on face-to-face communication on many levels. More specifically architects connect with clients, material suppliers, workers, other experts who work collaboratively with architects like electrical or structural engineers. These meetings and communication needs to be in crowded spaces which are considered a prohibited action with in the current state of COVID-19 [4].

The effect of crowding can be seen more clearer on construction sites, site offices and workers temporary dormitories, where the number of workers is usually large, such an environment is usually accompanied with lower health and hygiene services [4]. In addition, the current limitations of social distancing and isolation not being exist cause significant delays in the execution of projects.

To elaborate more about the relation between spaces and crowds' versus COVID-19 spreading nature; COVID-19 virus transmitted to humans via the aerosols whilst in earlier studies it was only thought to be a droplet borne disease and would be controlled via personal protective equipment (PPE). With these insights the crowding affect can be easily linked to the fast spreading of the virus within less spacious areas where it had

been seen that most crowded countries like India and china were the ones with the highest records of COVID-19 as it is given in Figure 3 [4]. Another factor to consider regarding the crowd management within the construction sector is the mobility of workers stations. Construction workers are most often shifted from one site to another including their mobile site offices and dorms. Such a factor can contribute greatly in the dispersal of the virus if not managed properly but the site architect or the site inspector. Mostly workers locations are considered to be congested and had health related issues in most countries, yet it had been ignored hence it was not affecting the sectors' financial profit aspect. However, now it is considered one of the main factors of the sectors decrease in financial benefit and when looking at a field that is seen to be a highly technological based especially when studying how the BIM system had elevated the quality of projects' processes execution on many aspects. As a result, the experts in the related fields must now develop the system tools to be pandemic ready in order to prevent regress that is similar to the one happening at the moment.

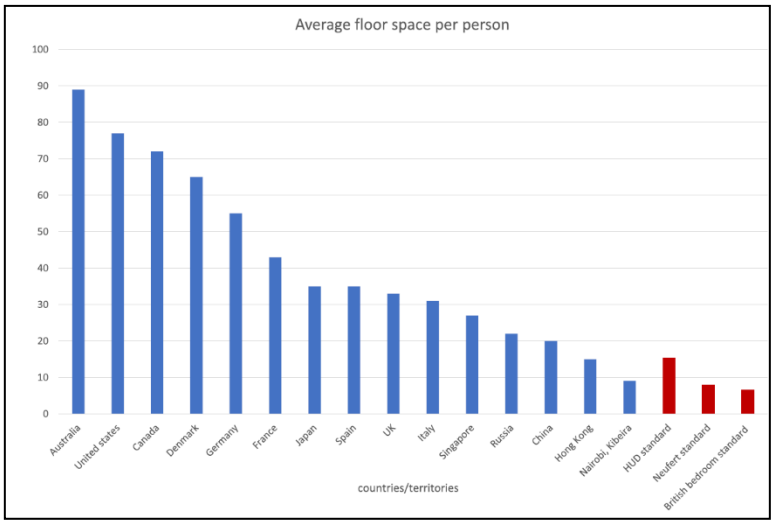

Figure 3: comparison of average floor space as living area (in square meters) per person in different countries/territories. (Blue bars: reported average floor space; red bars: minimum suggested floor space by different standards)

COVID-19 virus spreading nature had seen to be developing from being droplet based to aerosol. It had been seen that the virus allocate itself on various surfaces with different time periods. The distress caused by polluted surfaces connected with COVID-19 had increased in the past year during the pandemic period [5]. Focusing on the building supplies they gather many virus transmittal traits of mobility and crowding hence they are being transported between many locations till they reach their final destination in addition they are being examined and been in contact with a lot of people. Such behavior is considered as difficult to contain or to track and that is falls into the reason that there is no clear system established that is connected with the material suppliers with the BIM module of a project thus practicing isolation on materials or their transportation means lead to a significance postponement in the projects' timeline.

In terms of tracking and management aspect on construction site; since the fact that construction sites and architectural firms are considered a very active locations where the visitors' numbers cannot be tracked and that is due to the reason that some visitors and costumers might actually be there just for one time or few times only and they have no relation to any future project to keep their records.

On the other hand, some professionals in the field in management and construction who are considered to have interest in the technological boost come along with as a COVID-19 side effect. One of the main tools that has been recommended to offer better controlling in offices and sites during this pandemic is the use of drones and connect them to live-stream screen that can be accessed by the projects' supervisions and site architects in order to offer them real-time monitoring of the progress of the work.

However, this technology has its own difficulties to face by the professions in the field. The financial aspect of this recommendation must be taken into consideration; hence not all project supervisors might be able to obtain these tools to offer, especially in poor economy countries or for start-up architectural firms. Another aspect must not be overlooked is the technological literacy that many professional in the field does not obtain. Mainly architects and project managers use certain types of construction and design software's more over there is the contractors and construction workers who are even with much less related skills. If any architecture firm decides to apply such a solution, must consider a training period and implement it in their management strategies during this pandemic. Also, that might cause delay in the execution of the projects for some times

hence the time were introducing such tools and technologies moreover in planning and providing the training will also cause projects to be on hold .

IV. CURRENT STATUS OF BIM MODELING ON FACILITIES MANAGEMENT

From the beginning of the introduction of the BIM system into the construction field it had been seen as a very effective tool however few matters were taken as issues that needed to be worked on for a better system to be used. For instance; an improved alignment with the architectural process, an advance improvement of the BIM connection in real time means and directly record the costumer's feedback, comments and suggestions. Another topic to highlight is the availability of models to assist in the design stage of the project, more over an idea can be integrated into the system is the introducing of learning from mistakes that it makes by itself which can be titled as artificial intelligence. More to mention is that the older versions of BIM systems were suggested to establish a better coordination method to provide real-time monitoring, analyzing and presentation of data along with contextual information and GIS – geographic information system.

Examining the BIM system development, it is observed that it also includes civil construction, integration of water systems, structural systems and other sectors that is connected to the architectural practice. However, the BIM has been considered a very developed system its utilization in the current market is not considered had to be reached to its full potential yet [2]. This fact presents the BIM system as a massive management tool where it can be seen as a highly capable tool for managing situation like COVID-19 crises in construction management.

Currently to manage projects a BIM-FM (building information modules with facilities management) system are being used when managing large and complex project especially infrastructure projects. The purpose of the merging of these two systems is to provide protection from COVID-19 infections in indoors environments by focusing on social distancing and crowd management. With this management solution which uses mathematical applications that calculate users' paths within the building's architects can easily provide a much safer solutions even through pandemics spreading, preventing any possible related obstructions or delays.

BIM-building modeling with in the FM-facilities management applications is considered to be a novel area that is covered by the experts of the field. The purpose of merging those two tools is to offer updated methods in building management along with the fact that is step also helps in identifying the challenged that might appear and the limitations of each tool hence it will also offer a way for future improvement [6].

To begin with the term facilities management or FM is a holistic reference that covers a large group of functions that are connected together in order to benefit organizations the employees related. With its complete trait from management to maintenance it had been seen after researching that is it considered to be one of the most useful tools to be merged along with the BIM system. Where the BIM system considered to be one of the most successful tools that offers generating, storing, supervision, swapping and distribution building information in an interoperable and recyclable way. However few challenges had been facing this merging of the two systems of both BIM and FM. The limited availability of processes meant for updating the already designed models with BIM is nominated as a main obstruction aspect BIM-FM application, hence the roles and tasks aren't clearly demonstrated regarding offering data and maintaining models.

Difference in contract management between BIM and FM contractors creates duplication of information given to the clients and sometimes it can be seen as an obstacle in the current condition of both systems. Technological differences between the systems also create few obstructions that need to be taken into consideration when mentioning the emergence of these two systems. The actual value of emergence of BIM in the FM applications can be stated in the handover period of the project; in this stage a lot of information is requested from the project's constrictors or the supervising architect information such as equipment lists, products data, warranties, spare parts lists. Thus, when integrated BIM system with its 3d dimensional modeling, spaces, building systems, finishes lists, etc., information's can be easily captured without the fear of the possibility of offering false or duplicate information to client as it demonstrated in the figure 4 below, which can happen if the FM system was used alone [6].

On the other hand, there is still several challenges that face the BIM system linked to the FM systems. There is any obvious lack of ways that shows the related profits of BIM in FM where that showcases that the market is not demanding for such technologies. Also, the incomplete knowledge of the needed standards for the purpose of application of these systems such as what type of data is needed by whom and during which stage. Moreover, there is a strong shortage of BIM skills in the FM sector, along with the fact that the sector is considered to be a rigid one in term approaching new technologies and processes.

Previously, when researchers studied the topic of applying the AR in the built environment field it was noticed that it can have an effect on the entire stages of building construction from planning, design, construction and operation (J Ren, 2016). Others, such as (J. Delgado, 2020) had established a study that AR systems is obtaining a traction among the professionals of AEC sector, the stage of merging the system is less than the VR systems which indicate that there is a low level of companies investing in the AR more than the VR

in the next 3 years. There is still a need to develop the tools in order for it to reach out the level of the industry to offer a proper collaboration that can be easily and properly used by clients and professions in the industry.

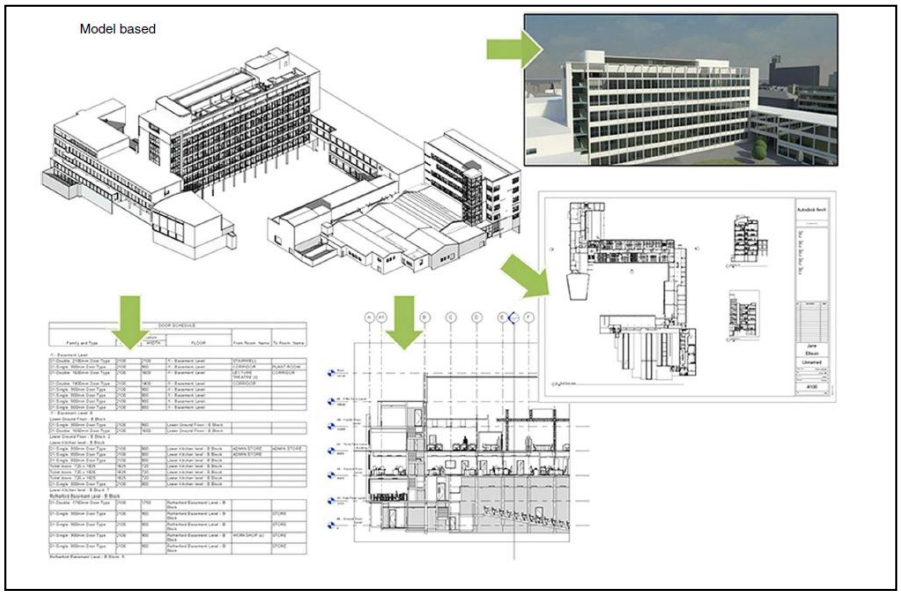

Figure 2: integration of BIM-FM system example [6]

The efforts of controlling the pandemic several efforts had been made on in commercial buildings such as restaurants; where distancing in designing the interiors had been taken into considerations, in addition to applying air filters and heat detectors for the purpose of maintaining the temperature with in the space with controlling the number of users with in the space hence it is a major aspect in controlling the pandemic [7]. On the other hand, hospitals and schools are also considered a main type of building that is hugely affected by the pandemic yet there is many regulations are being avoided especially regarding gathering within break hours. As it is mentioned by Selim, 2021 [7], there is a weak effort in controlling the crowds with in companies or on site where no measurements had been taken for this serious matter in-fact. There is few offices got 30 employees with in a single space which made several architects to actually work remotely. Despite the realistic situation of the management sector in the field there are high technological developments that are suggested by researchers offers architect effective ways to manage and control every step during a pandemic.

V. PROPOSED SOLUTIONS TO OVERCOME OBSTACLES OF BIM

FM-BIM management models proposed for COVID-19 effect on construction management sector. This solution is considered to be most suitable with complex buildings. Hence the model is concentrating on educational frameworks with the BIM model that reflects either the geometric complexity of the building or the type of occupants with in it. When measuring system efficiency against the pandemic it is better to take complex projects as examples. For instance, by taking a school building that can host 4000 student it offers a great complex spaces groups that an advanced system can be tested in and get a reliable feedback regarding the issue [2]. BIM infrastructure is actually a project management system which can be accessed by users via the internet and they can access to all the BIM elements related to the project; such as ambient temperature or humidity.

Having access to environmental related parameter offer a powerful BIM model that can be used for management in any situation. For example, the model of a school contains data related to quantification of material, total students, room occupation, education equipment for maintenance such as desks and black boards or projectors. This model is considered for offering a solution for COVID-19 infrastructure management with full synchronization from one BIM model to the SQL data base. It offers either an internal BIM data such as maximum load of users with in one space, or external data like the number of users registered with offer filter of users registered with offer filter of the users in terms of their occupation [2].

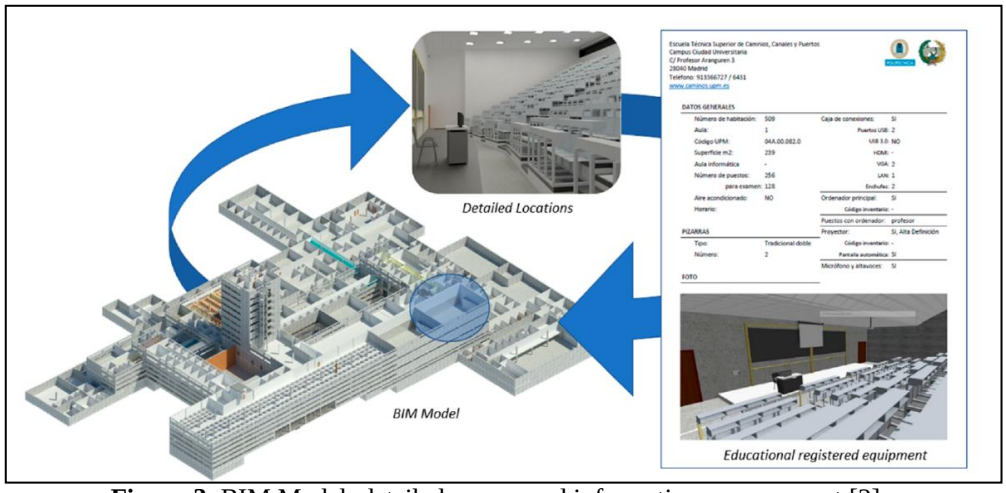

Figure 3: BIM Model, detailed spaces and information management [2]

Another tool had been introduced to the field especially when talking about management of construction sites is the usage of AR as in augmented reality systems. Since currently there is a proposal of inclusion of BIM with along with a 3D computer that provides prolific graphics for the design, construction and operation phase of the project; implementing architectural shapes with in the AR environment had been available [8].

AR is a tool that had been an essential tool on a fast base in the construction industry. Past researches reported regarding the topic of shifting the BIM model and the application of AR, or else using a wider section of AR by retrieving input depending on locations from the GPS. Moreover, when connecting AR to a cloud-based data base the connected system of BIM-AR offers the chance of viewing, interacting and collaborating with both 3D and 2D BIM data through geographically detached teams.

The proposed solution here is made in order to meet the expectation of developing a multi-user cooperative AR based tool which is able to be used at the entire phases of construction and design. The proposal goes as follows; offering a real time multi-user connection and interface via the AR system by merging the design information with the use of the BIM-process. Also, a real-time information transfer operation between stakeholders of the project, and the capability to add up and according to locate non-graphical data through both 2D and 3D information. The field of AEC offers space related data whilst all the phases of building but the skill of linking the data to an actual location is not yet offered in the BIM-AR platforms [8].

Many experts work with mobile devices to finish up their construction or design-based tasks to connect the 3D BIM information located in the AR with the use of mobile devices [9]. Correspondingly, since the AR is developing with the aspects of technology it offers multiple methods to located augmented objects in a real-world situation. And with the marker-based AR offering visualization tools, thus a need to merge these advanced tools to reach for a higher level of real-time synchronization is needed.

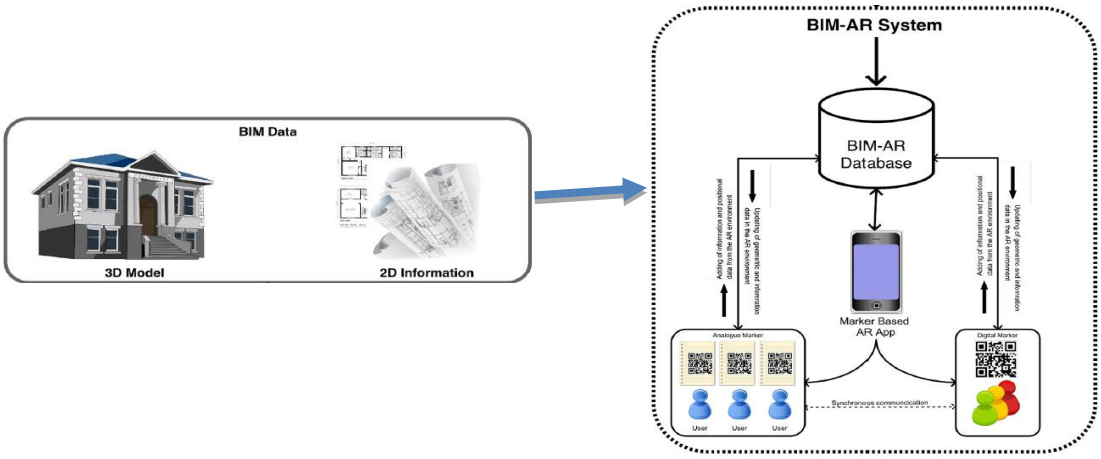

Figure 6: BIM-AR frame work proposal [9]

The approach that depends on the marker mask1 to the augmented reality application ARA had been used hence it provide the capability to give out markers on the physical based items as in papers or the digital ones such as large multi-touch devices. The availability in information gathering offers the ARA to function in various situations despite the limitations of technology that might happen. Thus, allowing different types of models to with a solitary piece of information similar to an architectural plan as in Figure 7. Moreover, a 3D model will be able to work in many ways; inclusive of shifting location, rotation and scale of the 3D information with no effect on the marker itself and with this technique it offers the ability of many users to manipulate the model without being limited by other users.

Figure 7: BIM-AR system architecture

Monitoring sites issue during COVID-19 pandemic was proposed to be solved with a solution that depends on a game like hybrid application of BIM. By utilizing the unity game engine integrates information from the original BIM model. The idea came from the fact that BIM models contain a vast amount of information that are made in the form of schedules, reports and photographs. The planned frame work has a conceptual model for an automatic imitation of construction projects, mixing game engines and BIM models [10].

In summary this method consists of object recognition and sematic2breakdown for structural elements identification as in figure 8 via an administered training to reach for the goal of overlaying the realistic images on the as-planned model. The presented frame work aimed for a computerized upgrade of a specific 3-dimensional environment with situations of the construction site [10].

Due to the complexity of the construction projects and the individualistic approach regarding each building on its own there is a good number of errors and delays can occur, thus there is a huge effect of information and communication technology regarding this matter. In order to upgrade the coordination between the projects' stakeholders' various methods or tools were proposed such as web-based technologies, cloud computing, BIM and tracking technologies [11, 12].

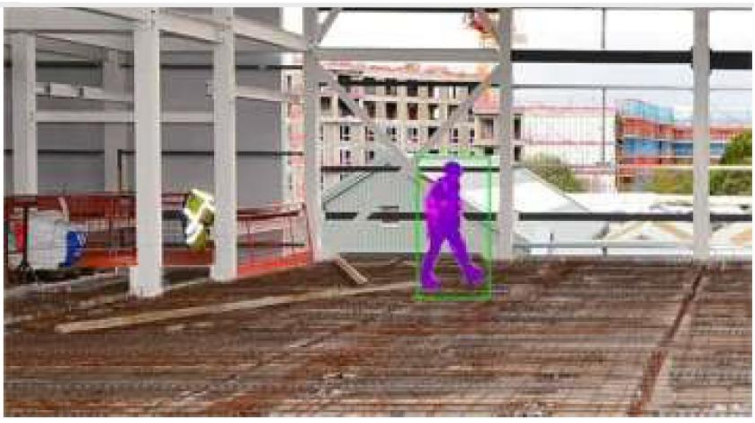

Figure 8: creating object mask with human recognition [10]

With computer vision and machine learning ML technological solutions are suggested to assist in preparing site photos along with the as-planned BIM models, and integrated with the help of the VR game engines like the Unity engine which allows the users to interact during the progression of the project allowing for error reporting task to be performed easily, Figure 8.

The prototype that was suggested as a response to the needs of monitoring construction sites was made along with the standards of remote construction monitoring with ML and image processing, noticing and obtaining building characteristics with layering them with the as-planned components with VR technologies such as Unity and HTC Vive to offer a virtual environment that allows for user interaction with the elements. With this method allows for site monitoring without creating obstruction on site and causing delays, in addition to time saving advantage [10]. This approach seems to be application considering its availability and its level of difficulty when compared to the current market yet more advanced techniques might be suggested in the future to provide more detailed information in terms of location with the assistance of located cameras and or drones.

VI. CONCLUSION

Pandemic are always seen as a trigger to change, everyone is affected, financial aspect of the sector. Since building construction industry had been usually seen to contribute in the environmental effects on a major pace. And for that purpose, managing projects in their processes one by one eliminate or reduce the effect of a virus spreading within a space. Despite the unpleasant situation of the industry in terms of construction site elements and persons presented on site as in crowd management. However, several advanced technological solutions were presented by researchers with the aim of reaching a high coordination and management level during the construction and monitoring buildings after being hard overed. FM-BIM a new that is made to enhance monitoring the items on a specific building in terms number of items and occupants which is extremely helpful in eliminating overcrowding via a single BIM-FM model that offers a single channel to the user where they can control and monitor the building from a web-based platform.

More development regarding the merging between the systems of BIM-AR to look forward to is the ability to access the AR related data with the primary BIM system without the need of the AR platform or the device as a medium for the process to be achieved such the usage of the mobile phone as mentioned earlier [9]. Similarly, another prototype was mentioned [10] that offers architects realistic time photographs of sites during the operational process depending on the sematic segmentation technology where they merge BIM models and gaming systems such as HTC Vive and Unity. Such technologies are seen to be very effective tool in controlling crowds and items such as architectural, structural, furniture or even users. The aspect of being able to control building from a distance is also a positive trait with these systems hence architects and supervisors where they can control and plan who can be on site and when preventing future spreading of the virus. Yet these technologies have on been tested for research papers and not much real time applications have been made due to cost and experience of the professional in the industry are the main aspects in delaying such an advanced development.

REFERENCES

[1]. Coates P., et al., The limitations of BIM in the arcitectural process. First International Conference on Sustainable Urbanization, 15-17 December 2010, Hung Hom, Hong Kong.

[2]. Ruben M.P., et al., Possiblities of BIM-FM for the management of COVID in public buildings. Sustainability, 2020. **12**(9974): p. 1-21.

[3]. Peleg K., et al., The covid-19 pandemic challenge to the all-hazards approach for disaster planning. International Journal of Disaster Rise Reduction, 2021. **55**(102103): p. 1-5.

[4]. Lorenz S., et al., Crowding has consequences: prevention and management of COVID-19 in informal urban settlements. Building and Environment, 2021. **188**(107472).

[5]. Knowles K.A., and Olatunji O.B., Anxiety and safety behavior usage during the COVID-19 pandemic: The prospective role of contamination fear. Journal of Anxity Disorders, 2021. **77**(102323).

[6]. Kassem M., et al., BIM in facilities management applications: a case study of large university complex. Built Environment Project and Aset Management, 2015. **5**(3).

[7]. Selim O. Founder of BIMarabia, BIM Project Manager | ACP | ACI | RICS| BIM implementation expert. (D. Muthana, Interviewer) 2021. **2**(17).

[8]. Garbett J., et al., A multi-user collaborative BIM-AR system to support design and consuntruction. Automation in Construction, 2020, *DOI:* 10.1016/j.autcon.2020.103487.

[9]. Ren J., et al., Architecture in the age of augmented reality: applications and practices for mobile intelligence BIM-based AR in the entire lifecycle. 2016 International Conference on Electronic Information Technology and Intellecturalization (ICEITI 2016), p. 664-674, 2016.

[10]. Rahimian F.P., et al., On-demand monitoring of construction projects through a game-like hybrid application of BIM and machine learning. Automation in Construction, 2020. **110**(103012).

[11]. Ibem E.O. and Laryea S., Survey of digital technologies in procurement of construction projects. Automation in Construction, 2014. **46** p. 11-21.

[12]. Rahimian F.P. and Gharib R.Y., Using IT/ICT as new meduim toward implementation of interactive architectural communication culture. Proceedings International Symposium on Information Technology, 2008. **9**(3).