Modelling Analysis and Design of Multi storey Helipad Park

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Abstract— With the increase in the number of road users and the need to transport personnel and goods to places of interest with convenience, alternative mode like the air transportation with no traffic and ease of its parking space features in commercial areas has been put forth in this paper. A Helipad park located on the top of a storey building would help to access a place of importance or a location with streams of people converging to it at the same time and with the same road network. This paper is aims to model, analyse and design a multi-storey helipad park. To achieve this aim, the results of two software applications were compared with the manual design. Autodesk Robot and CSI ETABS were the applications used. The building has a storey height of 3 metres with 4 floors and the helipad slab deck. The building was then subjected to both gravity and wind load for analysis. The result of a critical beam on the helipad deck was then compared using both the software applications and manual design. The maximum bending moment (Support) for the beam using the Robot Structural analysis software was found to be 305.66 kNm while that gotten from manual analysis was found to be 327.58 kNm. Also, the maximum shear force for selected beam using Robot software was found to be 362.73KN while that from manual analysis was found to be 390.48KN.

Index Terms—Autodesk Robot, CSI ETABS, Helipad, Manual design

1 INTRODUCTION

All developed countries have a common focus of actualizing a high infrastructural facility. Infrastructures like suspended bridges, multi-storey buildings, roads, power plants, airports and helipad have helped to boost the economy of developed countries and ease the living conditions of its residents. The continuous rapid growth in the world's population has brought about a continual increase in the number of road users resulting in congestions on the traffic. Asoka et al. [1] observed that the population of urban residents has increased from about 30% to about 47% in 2000 and that in African countries, about 28% lived in the city a of 1980 while in 2006, the population has increased to 37%. This has brought about an intense land use which calls for maximization of infrastructural facilities. Prud'homme [2] classified infrastructures into transportation, water supply, water disposal, irrigation, garbage disposal, district heating, telecommunication and power. Associated infrastructures of transportation includes roads, bridges, tunnels, rail tracks, harbours and other means of transport.

The increasing number of urban residents has made land acquisition very costly and hence, making it difficult for car owners to effectively create parking space or lot for their vehicles. This has made residents to develop various means of creating a parking space within or above their building. An example of such is a multi-storey car park which uses a ramp to connect each levels of the multi-storey building.

A heliport substantially smaller than airport providing comparable services. The main Element of designing heliport is the landing area of helicopter which is called the helipad. The location of helipad can be near town to pick up patient during accident or at the top of some elevated structure. The touchdown and lift off area is Called (TLOF), the final approach and take-off is called (FATO). A load - bearing, generally paved area normally located in the centre of (TLOF).

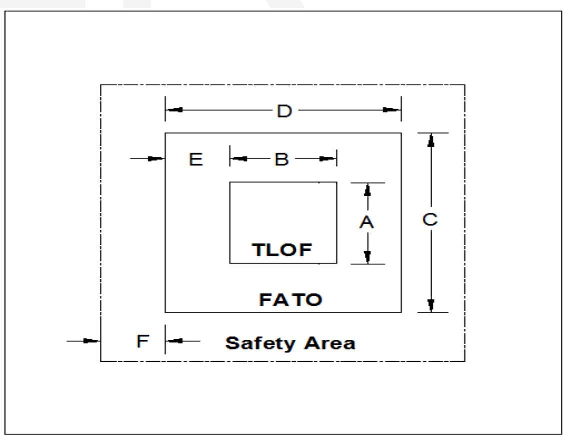

Fig. 1. TLOF and FATO safety area relationship (Sarbi, 2009)

A = Minimum TLOF Width 1.0 RD but not less than 12 m
B = Minimum TLOF Length 1.0 RD but not less than 12 m
C = Minimum FATO Width 1.5 OL
D = Minimum FATO Length 1.5 OL
E = Minimum separation between the perimeters of the TLOF and the FATO [0.5 x (1.5 OL -1.5 RD)]
F = Minimum Safety Area

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2 LITERATURE REVIEW

In the socio-economical interaction particularly, transportation has been and still is a substantial factor of human activity which permits a populace to extend and makes the growth of the economy of every country be evaluated by its infrastructure growth. Transportation, in some structure is fundamental and crucial part of the day by day cadence, bringing about robust movement of people and good, has also aided with the effective reciprocal action amidst different locations and as a consequence, it is then forming the wheel on which the economic activities count on to grow [3]. The use of the different transportation facilities keep increasing with the rapid growth of urbanization and ever population increase. The importance of technological development in the world including air transport in all regions of life and its effect on social activity and economy is well widely known which makes the aircraft to get in competition with other types of transportation by providing plenty services to passengers, goods and emergency patients for hospitals. At various phases of improvement and in various arrangements of circumstances, the nature of the interest for transport is liable to differ. Furthermore, in the present study field, helicopter is the air transportation material to be dealt with [4]. Helicopters generally come in different sizes with uncountable uses for civilian and military purposes. Their landing area can be described by the following typical and common names that are used interchangeably in many cases.

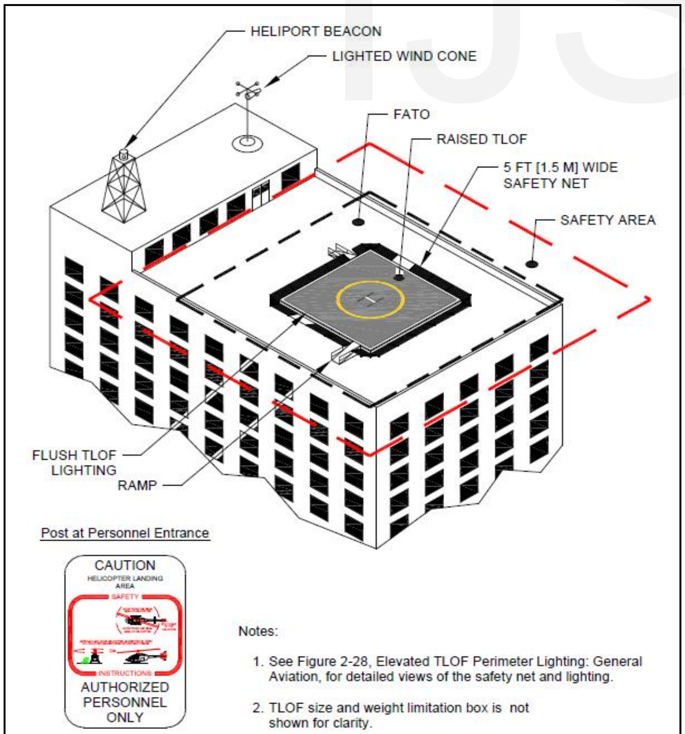

Fig. 2. Elevated Heliport: General Aviation [6]

The official name for formalized helicopter landing areas is Heliport with fuelling, passenger building and hangars; when it is with no fuelling, support facilities, it is defined as a helistop. Helideck are used to describe the actual landing surface of the heliport same as helipad which is the one we are going to use in this work. A helipad could simply be a temporary, cleared, level area [5].

A helipad is a helicopter landing pad or platform and designates a safe, identified landing area that is on an appropriate surface and while helicopters are able to operate on a variety of relatively flat surfaces, a fabricated helipad provides a clearly marked hard surface free from obstacles. Usually constructed out of concrete, the landing site of the helipad shall be marked out with a large circle with a letter H in the centre to make it easily to be spotted from the air. However, it is sometimes constructed out of timbers to receive supplies in remote areas and often, when on buildings, it has a number that indicates the maximum take-off weight of a helicopter in units of thousands of pounds [7]. The world's highest helipad built by India is located on the Siachen Glacier at a height of 21,000 feet (6400m) above sea level at a latitude of 35,5001596, a longitude of 77,0001698 [8]. Meanwhile, the world's largest heliport containing 46 helipads is located in Morgan City, Louisiana and it is mostly used to support offshore oil platforms in the Gulf of Mexico [9]. The multi storey helipad park is a major innovation in developed and developing countries and its requirement can be defended with the expanding number of rich Nigerians that can bear the cost of Jets and Helicopters and to offer alternatives to those that can manage the cost of it to beat the car influxes and bother on Lagos-Ota streets [10].

Helipad design criteria are mainly dictated by regulatory requirements and owner's preferences within the regulatory guidelines. The most important criteria are based on the availability of space, proximity of the obstruction around the site and the metro logical conditions. In addition, the design of the helipad is required to take the following items into consideration: the purpose for which the helipad will be used; the type and number of helicopters likely to use the helipad; the requirement of the parking spaces, the access road to the helipad, the ground manoeuvring of the helicopter, the security fencing, the facilities for hangar, the fire fighting vehicles, the ambulance, the refuters, the passenger lounge, the reception or departure paths for passengers, the air traffic control hut and air crew restrooms etc. [11].

The aim of this work is to model, analyse and design a multi-storey helipad park for the University of Ilorin, Nigeria. This is done by using two different software applications which are the Autodesk Robot and the CSI ETABS. The results of the two software are compared and then validated by designing a structural member manually.

3 METHODOLOGY

A four storey reinforced concrete building with each storey height of 3m is the proposed building for this work.

The steps and procedure involved in this work includes;

1. Drafting of architectural drawing of the multi-storey Helipad Park using AutoCAD.
2. Planning and generation of General arrangement of structural members from the architectural drawing.

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3. Model generation (using Autodesk Robot 2015 and CSI ETABS 2015)
4. Appropriate Load definitions.
5. Generation of the multi-storeyed helipad park.
6. Definition of model supports (fixed).
7. Definition of material (f_{cu}= 25N/mm²) and section properties.
8. Definition of static and lateral load cases.
9. Generation of load combinations.
10. Analysis and design
11. Generation of post analysis and design results and report.

Manual analysis and design of structural elements were carried out using the limit state design (ultimate and serviceability) method in accordance with BS 8110. The Analysis of selected 7-span beam for shear force and bending moment is shown below. This includes estimation of load for the top floor slab intended to carrying the helicopter.

The structural members analyzed and designed in this project include; slabs, beams and columns. A selected critical beam which carries the live load of 19.069KN/m² of Bell 409 Helicopter which was proposed is used for design of the structure was analyzed.

The storey information and element section properties which were inputted into the softwares for design are as indicated below:

3.1 Slab Definition

- 200 mm slab depth for Helipad touchdown and lift off area (TLOF), final approach and take-off (FATO) and safety area of the roof deck with a live load of 19.069 kN/m²
- 175mm for other slab areas on the roof deck with a live load of 5 kN/m²
- 150 mm for all the slabs from storey one to storey four with a live load of 2 kN/m²

3.1.1 Slab Definition

Self-weight of Slab 0.2 x 24 = 4.8 kN/m²
Finishes = 1.2 kN/m²
Load imposed by Helicopter = 19.069 kN/m²
Design load = 1.4 Gk + 1.6 Qk = 1.4(4.8 + 1.2) + 1.6 (19.069)
= 38.9104 kN/m²
Ly/Lx = 1 (2-way spanning slab)
Clause 3.5.3.7 BS 8110
$V_{sy}= \beta V_x N L_x$ =0.33 x 38.9104 x 5 = 64.2022 kN/m

3.1.2 Slab Definition

S/W of Slab = 0.175 x 24 = 4.2 kN/m²
Finishes = 1.2 kN/m²
Live Load = 5 kN/m²
N = 1.4 Gk + 1.6 Qk = 1.4(4.2 + 1.2) + 1.6 (5) = 15.56 kN/m²
Clause 3.5.3.7 BS 8110
$V_{sy}= \beta V_x N L_x$ =0.36 x 15.56 x 5 = 28.008 kN/m (Type 1)
$V_{sy}= \beta V_x N L_x$ =0.33 x 15.56 x 5 = 25.674 kN/m (Type 2)

3.2 Beam Section

- 750 mm x 230 mm for the continuous critical beams spanning underneath the helipad
- 600 mm x 230 mm for other beams of the roof deck.
- 450 x 225 mm for beams of storey one to four
- Wall load is taken as 10 kN/m

3.2.1 Beam Load Estimation (750 x 225 mm)

S/Weight of Beam = 0.225 x 0.750 x 2.4 x 1.4
= 5.67KN/m
Finishes = 0.6 KN/m
Wall Load = 10 x 1.4 = 14KN/m
Total Beam Load = 20.27KN/m

3.3 Column Section

- 750mm x 230mm for critical columns directly underneath the helipad
- 600mm x 230mm for other columns

3.4 Column Section

The load from the slab and also the beam (self-weight) were added and analysed by using Beamax. This gives the bending moment as well as the shear force diagram of the beam.

Slab (200mm) + Beam = 64.2022 KN/m + 64.2022 KN/m + 20.27KN/m = 148.674 KN/m
Slab (175mm) Type 1 + Beam = 28.008KN/m +28.008KN/m + 20.27KN/m = 76.286 KN/m
Slab (175mm) Type 2 + Beam = 25.674 KN/m + 25.674 KN/m + 20.27KN/m = 71.618 KN/m

A wind speed of 26 m/s was applied to the building with a wind coefficient of -0.8 windwards and -0.5 leewards.

4 RESULTS

The weight of the structure gives 3411715.63kg

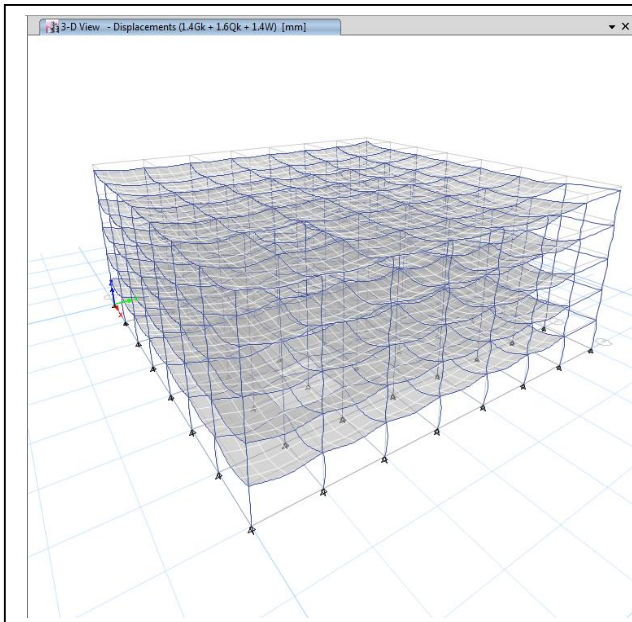

Fig. 3. ETABS Storey displacement

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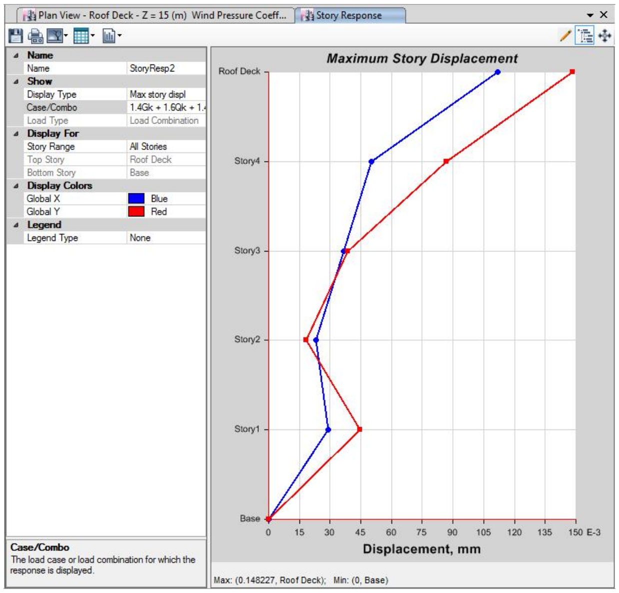

Fig. 5. CSI ETABS storey displacement of the building when subjected to wind load

ETABS gives a maximum storey displacement of 0.148 mm at the storey top under the action of wind load.

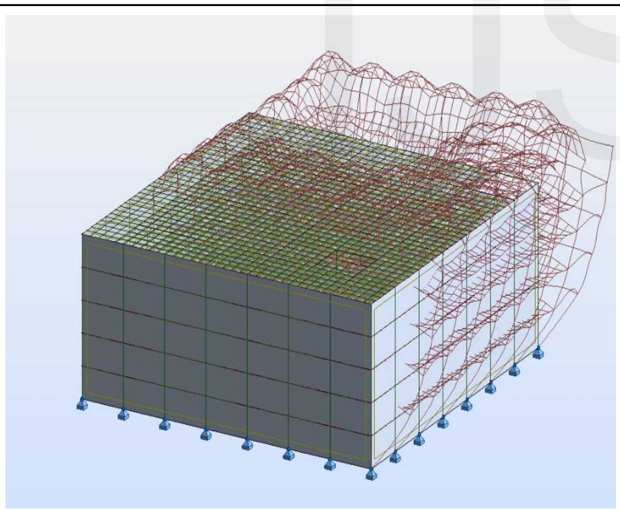

Fig. 6. Autodesk Robot building displacement when subjected to wind load

The Autodesk Robot software gives a maximum building displacement of 0.1 mm.

Figure 7 shows the beam loading, bending moment and shear force diagram of the selected beam by using Beamax.

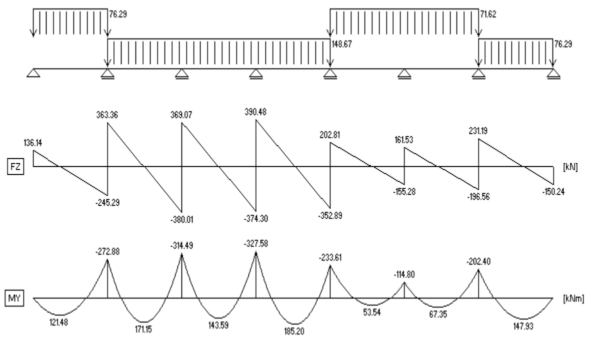

Fig. 7. Beam Loading, shear force and bending moment diagram

Estimated the Shear Force and Bending Moment to gives:
Maximum Shear Force: 390.48 KN
Maximum Bending Moment (Span): 185.20 KN / m^2
Maximum Bending Moment (Support): 327.58 KN / m^2

5 CONCLUSION

The software applications were found to reduce the time used in performing analysis needed for the helipad multistorey building. There is little difference in the result obtained from the two software applications in wind load deflections of the building. The maximum bending moment (Support) for the selected beam (most critical beam) using the Robot Structural analysis software was found to be 305.66 KNm while that gotten from manual analysis was found to be 327.58KNm. Also, the maximum shear force for the selected beam using Robot software was found to be 362.73KN while that from manual analysis was found to be 390.48KN. The difference in the output of the two results are due to the excessive factor of safety used in the manual load combination.

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