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Effect of Periodic Loads on G+3 RCC Building

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***Abstract*— The response of engineering structural components to a time varying load is of practical importance for the design of structures. This time varying load may be due to the acceleration imparted to the ground surface during earthquake or due to the wind forces acting on structure which can be approximated as periodic load. In this paper an attempt has been made to determine the response of a G+3 RCC building modeled in STAAD Pro when subjected to periodic loads. The building was subjected to rectangular, triangular and sinusoidal periodic load for 30s with maximum magnitude of 100kN and having time period of 1s. Further a comparative study was conducted to determine the response of such loads on front, roof and side surface of the building. It was observed that the critical deformations were obtained on the front and roof surface of the building. It was also observed that the variation of critical deformation along the height of building is parabolic in nature with maximum deformations at the top surface of the building. Moreover, it was also concluded that the velocity and acceleration with which the surfaces of the building vibrate, when subjected to periodic load was critical.**

Keywords*— Periodic; Time Varying Load; Critical Deformation; Load History; STAAD Pro.

I. INTRODUCTION

Building structures are frequently subjected to loads that are arbitrary in nature. These time varying loads may be due to the acceleration imparted to the ground surface during earthquake or due to the impulse forces acting on the structure or may be due to random periodic loads. A periodic load is a load that repeats its value after some definite interval of time. Most of the forces are periodic or nearly periodic in nature. A wind force induced by shedding on tall and slender structures is the best example of periodic excitation imposed to the building. These forces are dynamic in nature and may cause catastrophic damage to the building leading to the collapsing of walls. These forces may also lead to lateral instability of the building due to the alternating nature of load which repeats its nature after definite time period.

The response of engineering structural components to a time varying load is of practical importance for the design of structures to resist damage. Analytically, the response of periodic loads in building structures is determined through Fourier transforms [1] considering the weight of each storey as lumped mass. However, for multi-storey buildings or complex structures the response of these periodic loads is determined using computer softwares, such as STAAD Pro, SAP2000 etc. The typical load history of periodic loads is as shown below in Fig. 1.

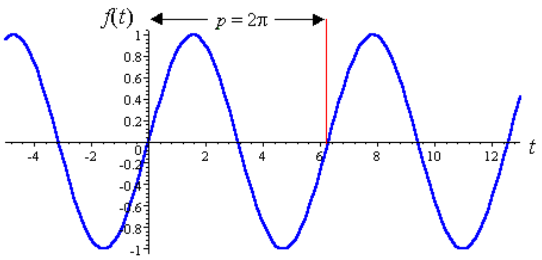

Fig. 1: Typical load history of periodic loads

II. LITERATURE REVIEW

Periodic loads are the most commonly encountered loads acting on the structures. These forces may act on the building surface in the form of wind loads. They may also be imparted due to the shock vibrations on the ground surface during earthquake and it is the response of the structure to these types of loads that will be the primary focus of this paper. Several anlaytical and experimental works have been conducted in past to study the response of structure subjected to these loads.

Philip Esper [2] studied the behavior of structural components subjected to periodic blast loads after 4 major bombing incidents took place in Mainland UK. The finite element analysis technique was used in the investigation of damage and their correlation with laboratory and onsite testing results was obtained. It was concluded that the ductility and natural period of vibration governs the reponse to periodic loads.

I K Khan [3] analyzed the performance of reinforced concrete beam under point impact loading. Impact load was applied at the mid span of the RC beam by continuously dropping steel weight of 25.4kg with a velocity of 4.14m/s. It was observed that with the increase in grade of concrete crack width and number of cracks was reduced in tension zone. It was also concluded that the load carrying capacity of the beam can be improved by increasing the area of steel in the beam.

Priyanka M et al [4] analyzed a ground floor column of a multi-storey building with varying concrete strengths for periodic loads. It was found that with increase in concrete compressive strength, the column size can be effectively reduced. Shear failure was found to be the dominant mode of failure for such loads. It was also concluded that the periodic loading was very different from static loading in terms of structural response.

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S. Tembhurkar [5] performed a critical review analysis of framed building structures subjected to wind loads. The wind loads were estimated based on the design wind speed of the zone in which the building was located using IS 875 code. It was found that the wind loads were more critical in bending moment, shear force and deformations.

III. BUILDING MODEL

The structure selected for this study is G+3 storey RCC building subjected to periodic load with maximum magnitude of 100kN on front surface of the building (in +X-direction). The overall length and width of the building is 8.0m and height of the building is 13.0m. The beam dimensions used are 250mm x 250mm and the column dimensions used are 300mm x 300mm. The thickness of the slab is taken as 230mm. The building was modeled in STAAD Pro and was further anayzed for rectangular, sinusoidal and triangular periodic loads acting on front surface of the building for 30s. The STAAD model of the building is as shown below in Fig. 2.

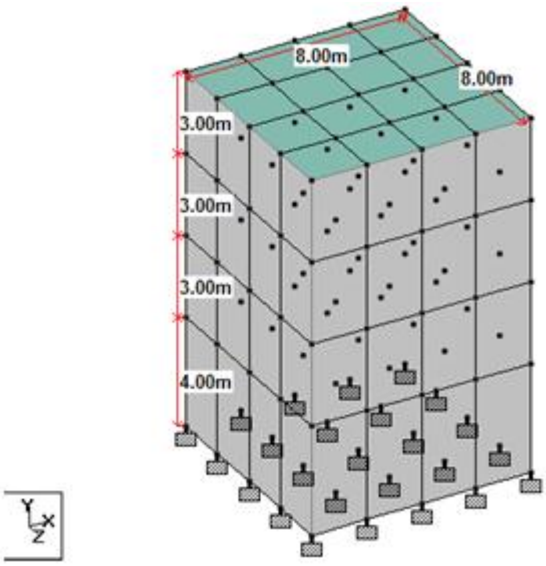

Fig. 2: STAAD model of G+3 RCC building structure

The Poisson's ratio for concrete is taken as 0.17 and the unit weight of concrete is taken as 24kN/m^3. Building is assumed in zone III according to IS 875 Part 3[6] for calculation of wind load on the building. The basic wind speed for analysis of building is taken as 47 m/s. Building is considered to be partially enclosed and the bottom portion of the wall is taken as fixed.

IV. ANALYSIS OF THE BUILDING MODEL

In this model, the coordinate system has been considered as length of the building along X-direction, height along Y-direction and width along Z-direction. The building is subjected to rectangular, triangular and sinusoidal periodic force on the front surface of the building for 30 seconds. The periodic load applied on the building has the maximum magnitude of 100kN and time period of 1s. For analysis of the building model, each surface of the building was divided into 16 equal parts and each part of the front surface was subjected to load history of different periodic forces. The RCC building was modeled in STAAD Pro and was further analyzed to obtain the results.

A. Rectangular Periodic Load

The load-time history for rectangular periodic load is as shown below in Fig. 3.

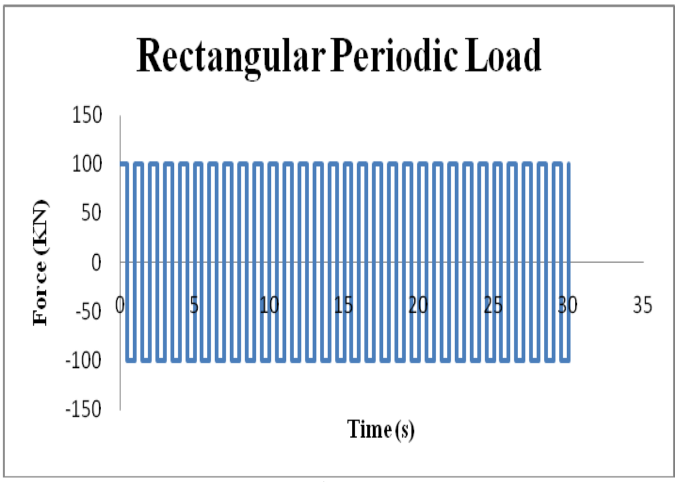

Fig. 3: Load history of rectangular periodic load

The maximum deformation on the front surface occurs at a height of 10m from bottom surface of the building. The time-displacement relation is shown below in Fig. 4.

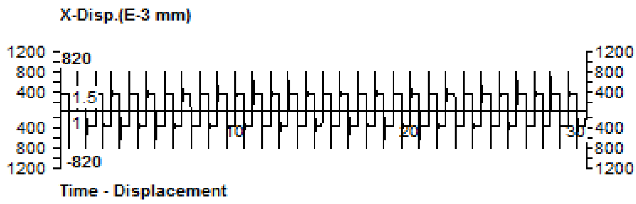

Fig. 4: Critical deformation on front surface of the building

The maximum deformation on the roof surface occurs at the joint where roof surface, front surface and side surface join. The time-displacement relation is as shown below in Fig. 5.

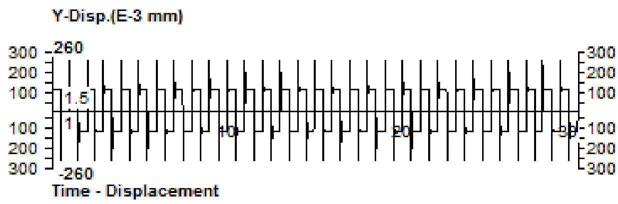

Fig. 5: Critical deformation on roof surface of the building

The maximum deformation on the side surface occurs at a height of 4m at the joint where side surface and front surface meet. The time-displacement curve is as shown below in Fig. 6.

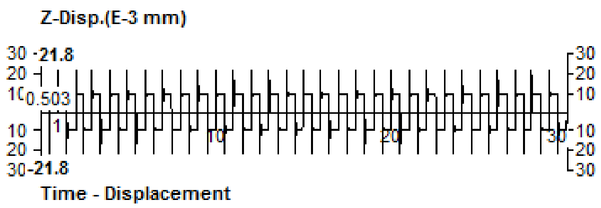

Fig. 6: Critical deformation on side surface of the building

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B. Sinusoidal Periodic Load

The load-time history for sinusoidal periodic load is as shown below in Fig. 7.

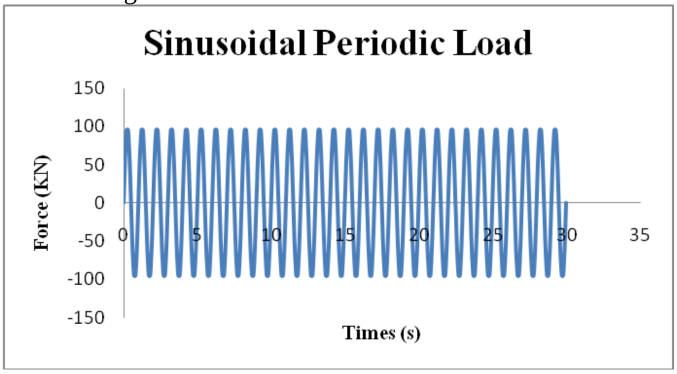

Fig.7: Load history of sinusoidal periodic load

The critical deformation on the front surface of the building occurs at the centre of top surface of the building. The time-displacement curve is as shown below in Fig. 8.

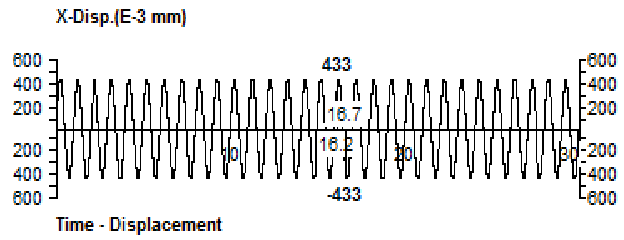

Fig. 8: Critical deformation on front surface of the building

The critical deformation on roof surface occurs at the joint where front surface, roof surface and side surface join. The time-displacement curve is presented below in Fig. 9.

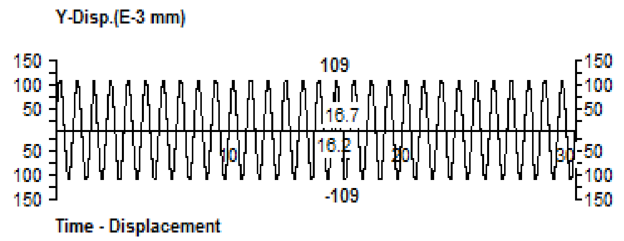

Fig. 9: Critical deformation on roof surface of the building

The critical deformation on the side surface occurs at a height of 4m at the joint where side surface and front surface join. The time-displacement curve is as shown below in Fig. 10.

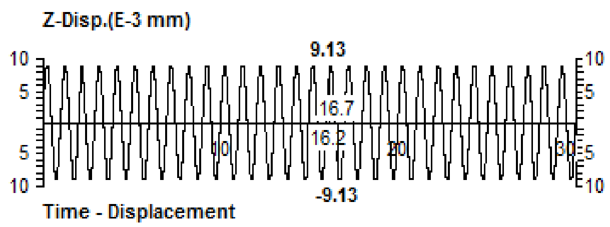

Fig. 10: Critical deformation on side surface of the building

C. Triangular Periodic Load

The load-time history for triangular periodic load is as shown below in Fig. 11.

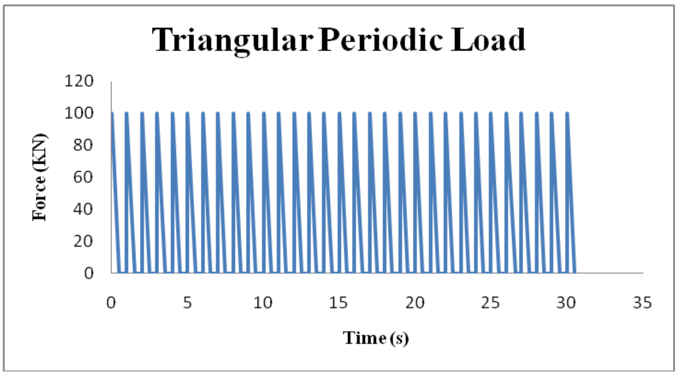

Fig.11: Load history of triangular periodic load

The critical deformation on the front surface occurs at the centre of top surface of the building. The time-displacement relation is as shown below in Fig. 12.

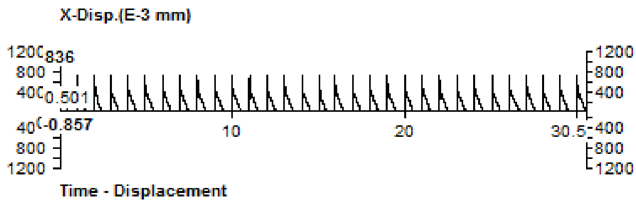

Fig. 12: Critical deformation on front surface of the building

The maximum deformation on the roof surface occurs at the joint where front, roof and side surface of the building join. The time-displacement curve is shown below in Fig. 13.

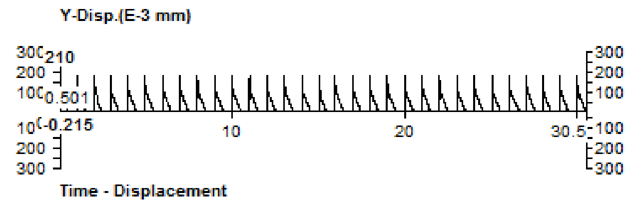

Fig. 13: Critical deformation on roof surface of the building

The critical deformation on the side surface occurs at a height of 4m at the joint where side surface and front surface join. The time-displacement curve is as shown below in Fig. 14.

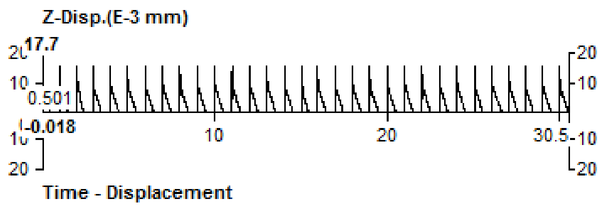

Fig. 14: Critical deformation on side surface of the building

D. Effect of Different Periodic Loads on RCC Building

To study the effect of different periodic forces on RCC bulding the rectangular, triangular and sinusoidal periodic loads with maximum magnitude of 100kN and time period of 1s were applied on the front surface of the building for 30s. The critical deformations obtained on different surfaces of the building are presented below in Fig. 15..

TABLE I. EFFECT OF RECTANGULAR, SINUSOIDAL AND TRIANGULAR PERIODIC LOADS ON DIFFERENT SURFACES OF THE BUILDING

Types of periodic load	Rectangular periodic load	Sinusoidal periodic load	Triangular periodic load
Front Surface (mm)	0.820	0.433	0.836
Roof Surface (mm)	0.260	0.109	0.210
Side Surface (mm)	0.022	0.009	0.018

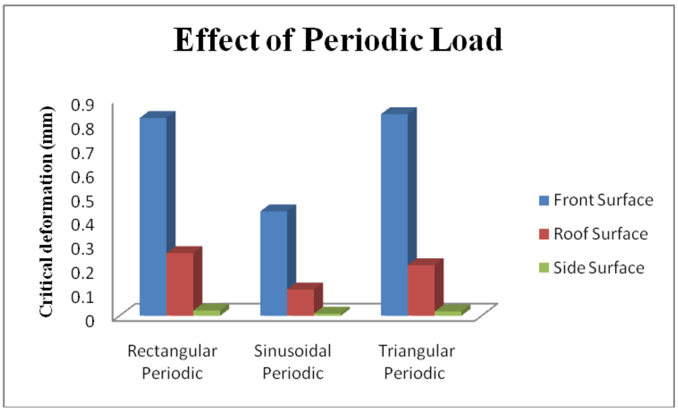

Fig. 15: Effect of rectangular, sinusoidal and triangular periodic force on different surfaces of the building

V. CONCLUSIONS

In the present study, extensive work was carried out to study the effect of periodic loads on G+3 RCC building modeled in STAAD Pro. The various periodic loads were applied on the front surface of the building for 30 seconds with maximum magnitude of 100kN and having time period of 1 second and following conclusions were drawn.

1. The maximum deformations obtained on the RCC building were within the tolerable limit but the velocity and acceleration with which the surfaces of the building vibrate were found to be critical.
2. The maximum deformations were obtained on the front surface of the building whereas the deformations on the side surface of the building were always within the tolerable limit even for very high periodic loads.
3. The deformations obtained on the roof surface of the building were also critical and hence to safeguard the building against such loads slabs should be designed as two way slab.
4. To impart sufficient ductility to the building, the reinforcement has to be provided on top and bottom surface of the roof. Since due to dynamic nature of load either surface can go in tension.
5. The variation of critical deformation along the height of building is parabolic in nature with maximum deformations at the top surface of the building.
6. Higher grade of concrete should be used for design of columns of building. Sufficient reinforcement should also be provided to impart stability against lateral loads. Circular columns with helical reinforcement should be preferred to impart stability against lateral loads.
7. Ductile elements such as steel and reinforced concrete should be preferred in construction as they can absorb significant amount of strain energy whereas brittle elements such as timber, masonry and glass should be avoided as they fail abruptly when subjected to such loads.

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