Dynamic Analysis of Military Bunker Subjected To Blast Load

Mr. Ashish Rajendra Yadav[1], Dr. S. K. Patil[2]
[1]Dept of Civil Engineering
[2]Associate Professor, Dept of Civil Engineering
[1, 2] KJ College of Engineering, Pune

Abstract- *The project deals with the analysis and design of a bunker constructed on three different soil types. Though each and every bunker has mostly similar components and machines but the analysis and design of civil structures in a plant are always done with different ideas and optimized techniques. Hence this paper is based on some new and different considerations in analysis and design aspects and optimization. The objective of this project also lies in knowing the difference between analysis and design of conventional structures and important structures or special structures. There are huge different machines in Military bunker which are subjected to axial thrust as well as vibrations. The structure results are found by means of 'ANSYS'. Optimum analysis results in optimum design. As earthquake ground shaking affects all structures below ground in case of an Military bunker and since some of them must sustain or withstand the strongest earthquake ground motion, they have to be designed and checked for different types of design earthquakes.*

Keywords- Dynamic analysis, blast, explosion, time history, ANSYS

I. INTRODUCTION

A bunker is a military fortification that is designed Military with the aim of protecting people or valuable goods from bombs or any types of attacks. Bunkers were extensively used during the First World War, Second World War, and the Cold War. They acted as command centers, stores for weapons, and distribution points

A. Explosions & Blast phenomena

An explosion is defined as a large-scale rapid and sudden release of energy. The explosion is a phenomenon of rapid and abrupt release of energy. An explosion in air generates a pressure bulb, which grows in size at supersonic velocity. The resulting blast wave releases energy over a small duration and in a small volume, thus generating a pressure wave of finite amplitude, travelling radially in all directions. Explosive is widely used for demolition purposes in construction or development works.

Only explosions caused by high explosives (chemical reactions) are considered within the study. High explosives are solid in form and are commonly termed condensed explosives. TNT (trinitrotoluene) is the most widely known example.

B. Objectives of study

1) To determine the effect on bunkers of varying blast loads.
2) To conduct research on finite element modeling of subterranean structures with an emphasis on the interaction of soil structures.
3) To create a model of a collection of subterranean buildings for Clay and Silty. Sand de sable pour la charge de l' explosion.
4) To compare the reaction of bunkers to different soil conditions in terms of total deformation, normal stress, and elastic strain.

C. **Confined explosion**

When an explosion occurs within a building, the pressures associated with the initial shock front will be high and therefore will be amplified by their reflections within the building. This type of explosion is called a confined explosion. In addition and depending on the degree of confinement, the effects of the high temperatures and accumulation of gaseous products produced by the chemical reaction involved in the explosion will cause additional pressures and increase the load duration within the structure. Depending on the extent of venting, various types of confined explosions are possible.

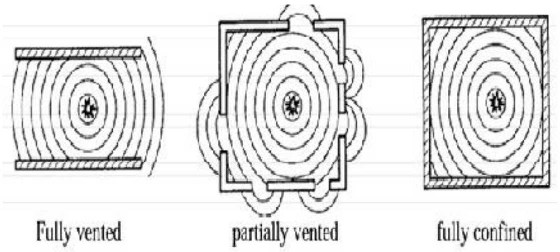


Fig 1fully vented, Partally invented and Fully Confined

II. LITERATURE REVIEW

Philip Esper in 2003 [1], The finite element (FE) analysis technique used in this investigation is described, and the correlation between the results of the FE analysis and laboratory and on-site testing is highlighted. It was concluded that the ductility and natural period of vibration of a structure governs its response to an explosion. Ductile elements, such as steel and reinforced concrete, can absorb significant amount of strain energy, whereas brittle elements, such as timber, masonry, and monolithic glass, fail abruptly.

LUCCIONI et al in 2005 [2],The accuracy of numerical results is strongly dependent on the mesh size used for the analysis. A 10 cm mesh is accurate enough for the analysis of wave propagation in urban ambient. Nevertheless, it may be too expensive to model a complete block with this mesh size. Alternatively, a coarser mesh can be used in order to obtain qualitative results for the comparison of the loads produced by different hypothetical blast events. Even coarse meshes, up to 50 cm of side, give a good estimation of the effects of moving the location of the explosive charges.

Ghani Razaqpur et al in 2006 [3] It was determined that the reflected blast pressure and impulse measured at the same location during different shots using the same charge size and standoff distance were generally reasonably close, but in some cases significant deviation occurred. The results of this study indicate that the GFRP retrofit may not be suitable in every situation and that quantifying its strengthening effects will need more actual blast testing rather than merely theoretical modelling or pseudo-dynamic testing.

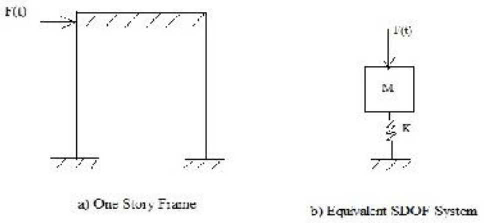
Ray Singh Meena in 2009 [4] The objective of this research was to test and compare its results to the deflections from blast loads using FEM of analysis and to compare them to equivalent loading response. It is recommended that additional research is to be done on the prediction of blast pressures on roofs and on the development of an equivalent uniform dynamic load. It is also recommended that an analytical resistance function for open web steel joists be clearly defined, which includes all failure limit states.

Ngo ET AL in 2007 [5], The structural stability and integrity of the building were assessed by considering the effects of the failure of some perimeter columns, spandrel beams and floor slabs due to blast overpressure or aircraft impact. In addition to material and geometric nonlinearities, the analyses considered membrane action, inertia effects, and other influencing factors. The results show that the ultimate capacity of the floor slab is approximately 16.5kPa which is 2.75 times the total floor load (dead load plus 0.4liveload).

III. METHODOLOGY WORK STUDY

The basic analytical model used in most blast design applications is the single degree of freedom (SDOF) system. A discussion on the fundamentals of dynamic analysis methods for SDOF systems is given below which is followed by descriptions on how to apply these methods to structural members.

All structures, regardless of how simple the construction, possess more than one degree of freedom. However, many structures can be adequately represented as a series of SDOF systems for analysis purposes. The accuracy obtainable from a SDOF approximation depends on how well the deformed shape of the structure and its resistance can be represented with respect to time. Sufficiently accurate results can be obtained for primary load carrying components of structures such as beams, girders, columns, wall panels, diaphragm slabs and shear walls. The majority of dynamic analyses performed in blast resistant design are made using SDOF approximations. Common types of construction, such as single story plane frames, cantilever barrier walls and compact box-like buildings are approximated as SDOF systems.



a) One Story Frame b) Equivalent SDOF System

Fig 1SDOF System

A. Multi-Parameter Models

To capture the shear transfer in the soil with a structural model, it becomes logical to introduce an interacting element to couple the independent springs in the Winkler model,

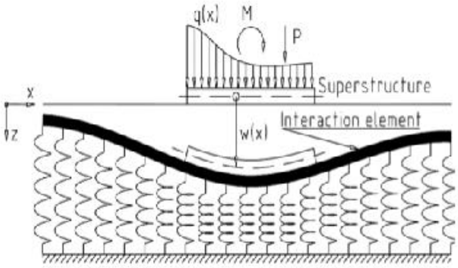


Fig 2 Visualization of a two parameter model. Adapted from (Teodoru, 2009).

B.Methods of Seismic Evaluation

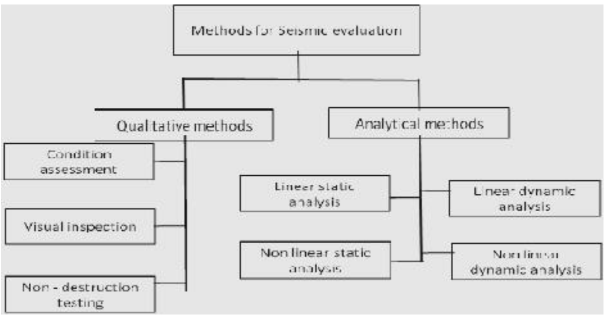


Fig 3. Different methods0of seismic0evaluation

IV. PROBLEM STATEMENT

In this chapter Military tunnel with soil structure interaction with clay, silty and sandy soil including material properties given in chapter 3 and Finite element models are analysed for static loading as well as dynamic loading (time history analysis). An Military bunker having three main parts namely, Access tunnel, Bunker cavern unit and a Transformer cavern is analysed. The dimensions of the tunnel are as follows:

	Width	Side Wall Height (m)	Arch Height (m)	Length (m)
Bunker Cavern	20	24	5	47
Transformer cavern	10	10	3	14
Access Tunnel	6	4	3	43

A Military bunker project is carried out in a fractured soil mass. It consists of a series of Military structures. Three main parts of the bunker are analysed in this study: the bunker cavern, transformer cavern and access tunnel. The domain of rock mass with dimensions 130 m X 114 m X 110 m is considered. Three joint sets are identified based on the analysis of the collected data from field survey, and the detailed information is shown in Table 3. Three types of surrounding soils are considered in this paper, clayey, silty and sandy soil conditions. The effect of earthquake waves on each of the soil types and the ultimate effect on the bunker structure is analysed with the help of ANSYS. Specified earthquake motion El Centro is considered for 31sec and implemented in ANSYS.

V. RESULT AND DISCUSSION

A. General

The main objective of this study is to examine the behavior of a military Bunker structure in different soil conditions during seismic excitation. The soil types considered are

1. Silty Soil
2. Sandy Soil
3. Clayey Soil

Table 1. Total Deformation values for the three Soil Types.

TIME	SILTY SOIL	SANDY SOIL	CLAY SOIL
1	2.20E-02	4.52E-02	1.28E-03
2	0.10916	0.22435	1.47E-02
3	4.50E-03	8.54E-03	0.1117
4	9.17E-03	2.02E-02	1.79E-02
5	1.39E-02	3.00E-02	3.49E-03
6	7.20E-03	1.34E-02	3.39E-02
7	1.51E-02	3.25E-02	1.42E-02
8	3.98E-03	6.10E-03	6.21E-03
9	2.79E-02	5.88E-02	9.51E-03
10	1.21E-02	2.63E-02	3.58E-02
11	1.42E-02	2.76E-02	1.84E-02
12	1.35E-02	2.92E-02	2.37E-03
13	4.42E-03	1.03E-02	1.92E-03
14	6.07E-02	0.1234	3.76E-03
15	5.32E-03	8.44E-03	4.41E-02
16	9.82E-03	2.18E-02	9.33E-03
17	1.98E-02	4.24E-02	3.59E-03
18	8.03E-03	1.79E-02	1.29E-02
19	6.23E-03	1.14E-02	1.41E-02
20	1.64E-02	3.21E-02	1.47E-02
21	1.12E-02	2.14E-02	2.14E-02
22	6.98E-03	1.29E-02	1.39E-03
23	1.04E-02	2.30E-02	5.01E-04
24	9.03E-03	1.71E-02	9.88E-03
25	1.87E-02	3.67E-02	2.75E-03
26	4.80E-02	9.70E-02	1.26E-02
27	1.25E-02	2.41E-02	3.49E-02
28	6.26E-03	9.88E-03	7.97E-03
29	6.96E-03	1.30E-02	3.89E-03
30	6.16E-03	9.75E-03	6.33E-03
31	6.16E-03	9.75E-03	1.26E-03

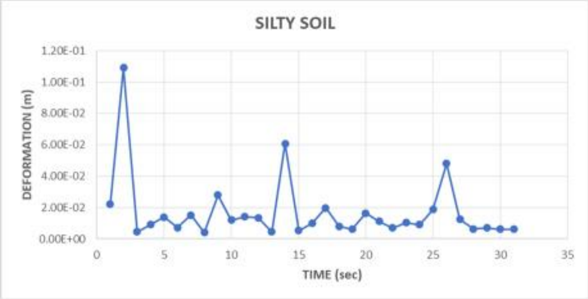


Fig 4 Graph of Time vs Deformation for Silty soil

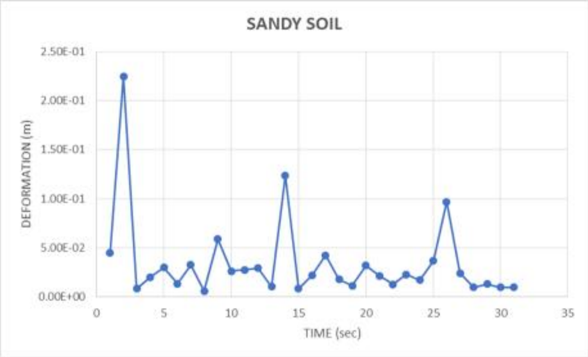


Fig 5.Time vs Deformation for Sandy soil

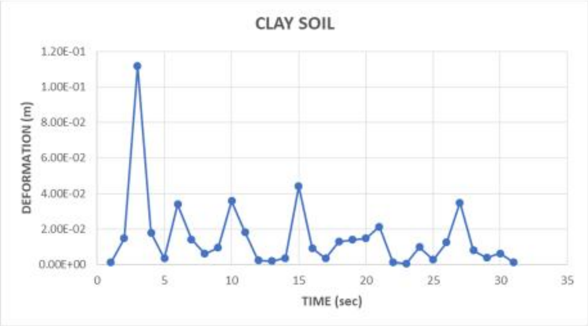


Fig 6.Time vs Deformation for Clayey soil

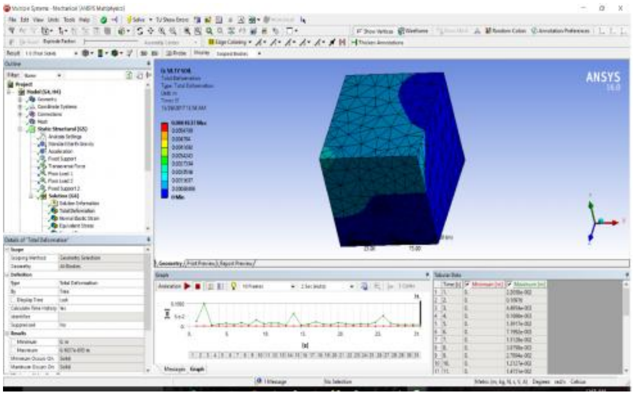


Fig 7. Total Deformation of Silty Soil Mass in ANSYS 16

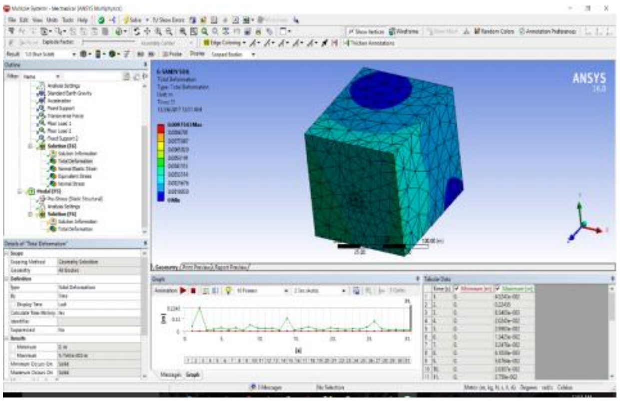


Fig 8.Total Deformation of Sandy Soil Mass in ANSYS 16

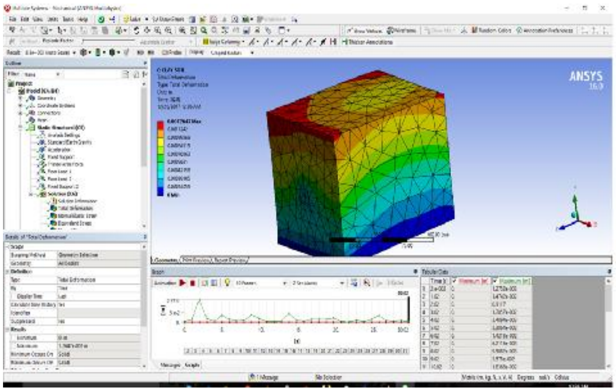


Fig 9.Total Deformation of Clayey Soil Mass in ANSYS 16

VI. CONCLUSION

1) In this study soil structure interaction of Military bunker is studied using FEA tool ANSYS 16. After applying El-Centro data it is observed that the total deformation, normal stress, shear stress and equivalent (von misses) stress are less in clayey soil as compared to Silty soil and Sandy soil.
2) Hence, as far as construction of an Military bunker is concerned clayey soil is best suited.
3) However, no abrupt change is observed in the natural frequency and time of structure.
4) All Military structures have to be checked and designed against earthquakes. In many cases the earthquake load combination will not be the governing one for the design.
5) Earthquakes are multiple hazards and all relevant ones have to be considered in Military structures.
6) Conceptual and structural measures are often more effective than sophisticated dynamic analysis.
7) Equipment's and components in caverns have to be designed against earthquakes similar to surface structures.
8) Tunnels for spillways and bottom outlets (including intakes, outlets and valve chambers) must be functional after the safety evaluation earthquake. Therefore, these

Military structures have to be designed for higher seismic hazard labels than any other Military structures.

9) Active fault zones in pressure tunnels need special attention especially when leakage can cause hydro-fracturing of the rock. Earthquake design of Military structures for is still in its infancy. Even ten years ago hardly any engineer would have considered earthquake action in Military structures in rock. However, for tunnels in soil seismic action had been considered much earlier..

REFERENCES

[1] Philip Esper in 2003 [7], after the Four major bombing incidents took place in Mainland UK within the last ten years; the 1992 St Mary's Axe, the 1993 Bishopsgate, the 1996

[2] LUCCIONI et al in 2005 [5], studied the effects of mesh size on pressure and impulse distribution of blast loads with the aid of hydro codes. A computational dynamic analysis

[3] Ghani Razaqpur et al in 2006 [1], investigated the behavior of reinforced concrete panels, or slabs, retrofitted with glass fiber reinforced polymer (GFRP) composite, and subjected to blast load Eight 1000 x 1000 x 70 mm panels were made of 40 MPa concrete and reinforced with top and bottom steel meshes

[4] Ray Singh Meena in 2009 [8], focused on the design techniques for the loading on roof structures and the resistance of open web steel joists, a common roof component. Blast loads are dynamic, impulsive and non-simultaneous over the length of a roof

[5] Ngo ET AL in 2007 [11], carried an analytical study on RC column subjected to blast loading and progressive collapse analysis of a multi-storied building were carried out.

[6] Alok Goyal in 2008 [2], discussed through an overview to quantify blast loads as high pressure, short duration shock loading for the building as a whole and on each individual structural component.

[7] H. Draganić “An Overview of Methods for Blast Load Testing and Devices for Pressure Measurement”hindawi Volume 2018 |Article ID 3780482

[8] Zeynep Koccaz “Architectural And Structural Design For Blast Resistant Buildings” World Conference on Earthquake Engineering October 12-17

[9] A. H. Chowdhury “Characterizing Explosive Effects on Underground Structures” September 2015

[10] Vasilis Karlos “Calculation of Blast Loads for Application to Structural Components” Blast Simulation Technology Development