Demolition of Structure Using Finite Element Analysis Software

Mr. Akash D. Tiwari[1], Prof. Mrs. Sneha Sawant[2], Dr. B.S. Balapgol[3]
[1, 2, 3] Department of Civil Engineering
[1, 2, 3] D.Y.Patil College of Engineering, Pune

Abstract- *Every structure in world limited lifespan in which they provide the service, at the end of their life it necessary to demolish the structure otherwise it is harmful of life. The main challenge is at the time of demolition is that demolished the structure in short time and properly controlled manner in less cost. The object of this work is optimize the time and cost of demolition process through planning, evolution and suggestion of suitable solution for demolition by identifying the problems at the time of demolition and factors affect the demolition . By study give a proper solution by using computational techniques i.e. by use of finite element analyses software to solve the problems. By using Ansys is as problem solver to find optimal use of explosives to be used and exact location of explosive in structure. The explosives are required to exceed the instantaneous compressive strength of the material in its immediate vicinity. Stress developed in structure is determine by the computational analysis shall be referred as a performance indicator . Safety aspect is also determined at the time of demolition and it is documented.*

Keywords- Demolition, Expiry structure, explosives, ANSYS, FEA

I. INTRODUCTION

The term “Demolition” implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or as shown on the drawings. Demolition of any structure is the process of destroying down or falling down or collapsing down of large buildings after its useful life period with the help of some equipment or other method with a legal procedure followed by the consent of the local authority.

When demolition occurs, it is usually a sign of coming growth, expansion, or renewal. Major cities in the United States and elsewhere are constantly renewed. Old factories are gutted and converted into new office spaces or residences. Industrial facilities are cleared to accommodate new machinery and equipment. Dilapidated housing is demolished to make way for new and more efficient residential uses.

Any demolition activity to start with, there are many steps that need to take place forehand including but not restricted to performing asbestos abatement, removing hazardous or regulated materials, obtaining necessary permits from the authority, submitting necessary notifications, disconnecting utilities, and development of site-specific safety and work plans for the workers as well as the surroundings with a detail planning of every stage with a working strategy. A demolition review ordinance should spell out specific criteria for determining which properties are subject to review.

Most communities require some level of review for all buildings or structures at least fifty years old, but others have restricted review to those at least one hundred years old. Other communities have applied demolition review to properties previously identified through a historic resources surveyor listed on the State or National Register of Historic Places. Finally, some communities decide to apply protection to a specific geographic area, such as a downtown or Main Street. In most cases, the historic resources survey or tax assessment records can verify the age of a building proposed for demolition. If no survey information exists, the burden of establishing the date of construction can rest on the applicant or can be left to the review body. Once a building or structure has been determined to meet the age or geographic criteria, the review body– often with the assistance of municipal staff – typically determines whether it is significant. Significance can be determined by analyzing the building’s association with historic persons or events, or with the architectural, cultural, economic, or social history of the community. The review process works best when a historic resources survey exists to verify a building’s age, as well as its architectural and historical significance, or where there is properly trained municipal staff to assist with the necessary research. In both Keene and on cord, for example, the demolition review committee, which is comprised of three members of the Heritage Commission, is responsible for conducting the initial review, making the official determination of significance, and holding the meeting to explore alternatives.

Demolition review is a preservation tool that ensures potentially significant buildings and structures are not demolished without notice to the community and review bylaw heritage or historic district commission. A demolition delay ordinance can be adopted as an amendment to the

building code, implemented as a stand-alone ordinance, or as a bylaw in an existing historic preservation or zoning ordinance. This legislation can be a very effective tool in helping to protect historically significant resources in the community.
Buildings when demolished with the help of explosions are called as an implosion a systematic technique of bringing down the structure. Demolition blasters load explosives on several different levels of the building so that the building structure falls down on itself at multiple points. When everything is planned and executed correctly, the total damage of the explosives and falling building material is sufficient to collapse the structure entirely, so clean-up crews are left with only a pile of rubble.

An implosion is an event where something collapses inward, because the external atmospheric pressure is greater than the internal pressure. For example, if you pumped the air out of a glass tube, it might implode. When a building is surrounded by other buildings, it may be necessary to "implode" the building, that is, make it collapse down into its footprint. You can demolish a stone wall with a sledgehammer, and it's fairly easy to level a five-story building using excavators and wrecking balls. But when you need to bring down a massive structure, say a 20-story skyscraper you have to haul out the big guns. Explosive demolition is the preferred method for safely and efficiently demolishing larger structures.

The basic idea of explosive demolition is quite simple: If you remove the support structure of a building at a certain point, the section of the building above that point will fall down on the part of the building below that point. If this upper section is heavy enough, it will collide with the lower part with sufficient force to cause significant damage. The explosives are just the trigger for the demolition. It's gravity that brings the building down.

Demolition blasters load explosives on several different levels of the building so that the building structure falls down on itself at multiple points. When everything is planned and executed correctly, the total damage of the explosives and falling building material is sufficient to collapse the structure entirely, so clean-up crews are left with only a pile of rubble.

II. LITERATURE REVIEW

The author [1] presents the Adaptively Shifted Integration (ASI) technique, which produces the highest computational efficiency in the finite element analyses of framed structures including static and dynamic collapse problems, is applied to the explosive demolition analysis and the seismic damage analysis of a reinforced concrete building. By expressing an explosion or a member fracture by a plastic hinge located at the exact position with a simultaneous release of resultant forces in the element, discontinuous problems such as these dynamic collapse problems can be easily analyzed even by the conventional finite element code with the displace mental form. By using the algorithms described in this paper, sufficiently reliable solutions for the practical use have been obtained in the explosive demolition and seismic damage analyses of a five stories-five span reinforced concrete building. This present technique can be easily implemented with a minimum effort into the existing finite element codes utilizing the linear Timoshenko beam element. By expressing an explosion or a member fracture by a plastic hinge located at the exact position with a simultaneous release of resultant forces in the element, discontinuous problems such as these dynamic collapse problems can be easily analyzed. It save time and cost.

In this technique the numerical integration points in an elastically deformed element are placed at the optimal points for linear analysis while the integration points are shifted immediately after the occurrence of fully plastic section in the element, using the reactions between the locations of numerical integration points and those of plastic hinges to form a plastic hinge to form a plastic hinge at the position of that section. Thus technique produces higher computational accuracy with fewer elements than the conventional method. An explosion or a member can be expressed by plastic hinge located at the exact position with simultaneous release of resultant forces in the elements, which produces the dynamic collapse of building with this proposed technique, discontinuous problems can be easily analyzed.

In this paper author [2] identifying the need for demolition technique and design safe and efficient deconstruction procedures. According to author in Germany there are about one million unoccupied apartments – most of them in precast concrete panel buildings. Although large sums of money have been expended on retrofitting these houses, German ministry of construction recommended demolition of as many as 350 thousands of apartments for which retrofitting is not feasible. Expected costs of the demolition run at _ 350 million, with some experts putting the figure even ten-times higher. To reduce these costs, new deconstruction methods are being developed. Due to their cost and time efficiency, demolition methods employing controlled explosions receive much attention. In order to safely and successfully perform the demolition, it is essential that appropriate sizes, placement and timing of charges are determined. In order to facilitate a conscious design of safe and efficient deconstruction procedures, a methodology for FEM-based simulation of collapsing precast concrete buildings has been proposed recently.

In a contrast to the standard structural analysis, when we want to simulate building demolition, the main interest is prediction of mechanical behaviour of the structure during the phase when it disintegrates and loses static stability. The mechanical phenomena to be dealt with include material fracturing and yielding on one hand, and dynamic motion (finite displacements and rotations) and interaction of debris on the other. Since even separate numerical analysis of each of these phenomena presents a complicated task, when we have to consider them simultaneously, a suitable computational strategy has to be employed. A typical precast concrete building consists of relatively stiff reinforced concrete members (panels), which are interconnected by rather weak joints. Structural failure in such a system usually occurs at or in the vicinity of the joints. The failure usually has a localized character and involves cracking and crushing of concrete and yielding and rupture of steel reinforcement. A detailed simulation of these phenomena generally requires two- or three-dimensional FE analysis with solid elements and nonlinear material models. Despite ever-increasing computational power, such an analysis is feasible at the level of an individual structural element, but performing this way a geometrically nonlinear transient-dynamic analysis of an entire building would be too costly. On the contrary, the latter can be efficiently analyzed using beam or plate elements. Thus, we model the whole structure as an assembly of deformable beam elements interconnected by fracturing joints

In this paper the author [3] identifies the problem faced in demolition of industrial building. To analyse the behaviour of the structure in question at the demolition by blasting, he have used The Applied Element Method, combining features of finite element method with discrete element method. The time for the complete analysis is reasonable and the accuracy of the results is satisfactory. In the paper he is present a way of checking and optimization of a demolition scenario at an industrial building based on controlled blasting method in order to transition to the actual demolition of the building in question. For this purpose he used a specialized computer system that describes the behaviour of the structure at exceptional actions, from the application of forces, the opening and propagation of cracks, the separation structural elements up to total collapse of the building. According to author simulation results validates the demolition scenario and the blasting parameters of the building . This analyse can also constitute the basis for effective achieve of this demolition. The demolition analysis, showed that the structure collapsed in the desired direction and after impact with the ground was compact broken without it result the projections with long-range which to endanger nearby dwellings.

The author [4] present optimization of blasting optimization of blasting strategies for the safe and economic demolition of large scale buildings by means of controlled explosives. Building blocks of the presented approach are i) an efficient multi-level simulation model for the collapse of the building, ii) appropriate optimization models and evolution strategies as optimization methods and iii) modern computer methods for the implementation of distributed software system for the planning of complex blasting projects. In the case of high rise structures and huge building complexes the demolition by means of controlled explosives has proven to be an efficient technology. The main advantage over conventional demolition techniques applying special machinery is the fact that the cost intensive application of men and machinery is primarily limited to the drilling of holes and loading them with the explosive charges in destined zones of the building. The main idea of virtually every blasting strategy is to eliminate vertical supports of the structure by the controlled explosions and to leave the rest of the work to gravity.

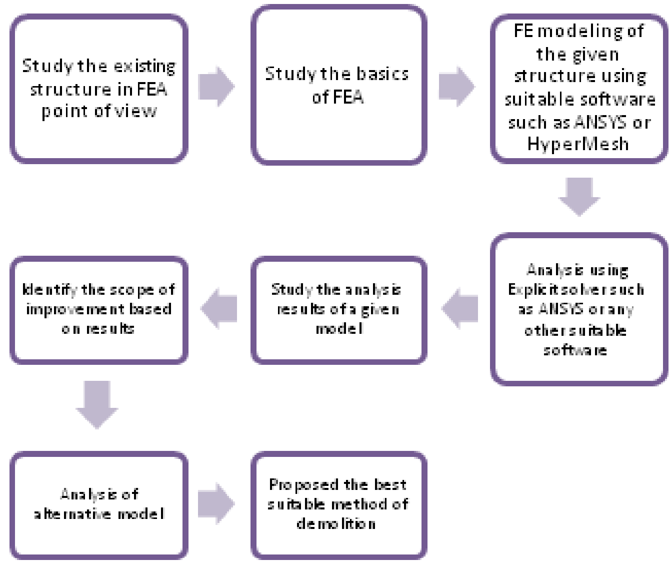
According to author in the planning stage, the engineer has to decide on the number and placement of the explosive charges and the time flow of the ignition. However, accidental blasting projects show that this traditional, empirical approach is error prone because it is a difficult task to determine the optimal amount and position of the charger zones and the sequence of ignition in order to have a efficient and safe demolition. This problem is addressed by different investigations on the numerical simulations of demolition processes by means of controlled explosives. A computer system for the planning of the demolition of chimneys by felling them into a predetermined fall plane has been developed. Researchers at the University of Tokyo have developed a lumped mass model based method for the simulation of collapses due to earthquakes that is also applicable to the simulation of demolitions by means of explosive charges. Other approaches like use the finite element method with special extensions to the numerical simulation of collapses.

The realistic and efficient simulation of a demolition of a structure by means of controlled explosives requires a powerful simulation model that covers the entire complex dynamic process that is evoked by the ignition of the loads and ends with the collapse of the building. The concept of the developed simulation model is therefore based on a multi-level model of the blasting process that comprises three main levels: On the first level (local level) the effects of the exploding charges are modelled such that the volitional damages can be captured and described. On the second level (near field level) the effects of the local damages on the adjacent structure are analyzed. Based on the first and second level, finally the collapse of the entire structure is modelled on the third level (global level) including fracture processes and relevant contact mechanisms.

The author [5] says that demolition of building at the end of their life become more and more important. These building have either no longer attractive in architectural sense or did not match required standard. To avoid damage of neighboring building or traffic facilities an accurate perdition of building collapse is needed. Otherwise uncontrolled collapse may cause great physical major collateral damage may. Using Finite Element Analysis model we controlled the unwanted collapse of building and save time and cost. The main advantage over conventional demolition techniques applying special machinery is the fact that the cost intensive application of men and machinery is primarily limited to the drilling of holes and loading them with the explosive charges in destined zones of the building. In this paper author uses finite element model to investigate the collapse. In this he proves that quality of prediction has been carried out. Author focus on influence of failure criterion to the prognosis quality.
The main problem of a demolition from the viewpoint of the engineer is that the dynamic structural behavior of the building during the collapse is not known. To give the engineer a tool for this prediction and to estimate the risk of a blast strategy the research unit 500 built up an analysis concept which investigates the important influences of the demolition by using explosives. The main goals are to produce a good a “priori” prognosis of the collapse belonging to a chosen blast strategy, as well as to consider uncertainties in geometrical and material data and to produce a computational tool for the practice. The concept considers different spatial levels and, as mentioned before, the uncertainties. Also, the verification and especially the validation of the results are important for the numerical analysis and are parts of the concept. The research unit is divided in four subprojects. Main goal of the project is an object oriented software system for the multi-level simulation and optimization of the demolition process by controlled explosives of reinforced concrete structures.
The goal of the investigations is to generate specific information about the collapse kinematics of buildings demolished by blasting. In this contribution a validation process is performed for an example of a reinforced concrete industrial structure with a toppling collapse sequence after the controlled blasting. Two model approaches are investigated which take into account the failure, especially the separation of structural parts. The approach without an erosion of the highly reinforced parts of the structure shows the best agreement with the validation data.

III. RESEARCH METHODOLOGY

The research methodology adopted for this study consist of following,



Computational methodology shall be deployed using FEA software for identifying the alternatives for the significant parameters influencing implosion. ANSYS software is identified as a suitable solver for conducting this exercise using virtual simulation.

ANSYS simulation software gives designers the ability to assess the influence of this range of variables in a virtual environment. Thus, engineers can advance through the design and materials selection process quickly and efficiently. ANSYS tools guide the user through coupled rock and soil mechanics analysis; material-specific maximum load assumptions; linear, nonlinear, static and dynamic analyses; sensitivity and parametric studies; and other related work — which together provide significant insight into design behavior that would be difficult with single analysis runs. Through visualizing the effect of a wide range of variables, engineers can narrow the scope of field investigations, save considerable time and cost on projects, and move more quickly to the groundbreaking stage.

The advanced capabilities of ANSYS software create a powerful tool for civil engineering projects as diverse as high-rise buildings, bridges, dams, tunnels and stadiums. By testing materials and experimenting with design in a virtual environment, engineers and designers can analyze safety, strength, comfort and environmental considerations. The result is cost-effective and innovative design.

In a contrast to the standard structural analysis, when we want to simulate building demolition, the main interest is prediction of mechanical behavior of the structure during the phase when it disintegrates and loses static stability. The mechanical phenomena to be dealt with include material fracturing and yielding on one hand, and dynamic motion (finite displacements and rotations) and interaction of debris on the other. Since even separate numerical analysis of each of these phenomena presents a complicated task, when we have to consider them simultaneously, a suitable computational strategy has to be employed.

IV. OBJECTIVES OF PROPOSED WORK:

The objectives of the work are as follows:

- Evaluate and identify demolition options for multistoried building.
- To study the suitability of an implosion technology for demolition of building through literature review
- To deploy computational techniques for determining alternatives for the parameters applicable to implosion (e.g. - Type of explosive, Amount of explosive, Placement of the explosive within the structure to be demolished).
- To optimize the solution through comparison of the alternatives analyzed
- Recommend the solution upon review.

V. CASE STUDY AND ANALYSIS

Following details of case study obtained from Ethika Engineering Solutions India Pvt. Ltd, whose office is situated at 5 Arya, RH-156, G-block, Shahu Nagar, MIDC, Chinchawad, Pune-411019.Site is situated in Hadapsar, Pune.

1) Type of structure ----------- R.C.C. framed structure.
2) Height of structure -------- G+5 story
3) Area of plot ----------- 1634.64 m^2
4) Area of structure ---------- 1230.62 m^2
5) Volume of Structure ----- 82.992 m^3
6) Mass of structure -----------192541.44 kg
7) Density ------------------- 2320 kg/m^3

Things to do before Demolition Begin

Explore asset and resource recovery of items normally left for demolition disposal. Prepare a clear and complete scope of work and discuss it in detail with the demolition contractor prior to starting work. Ensure that you receive guaranteed legal disposal of all demolition materials. Mark, cut and cap all utilities and communication lines to demolition area this action can result in double savings by reducing the cost of demolition service and bringing in cash for salvaged items. There are many companies that will pay you to remove your unwanted items but who don't do demolition work. This is an excellent way to productively fill a ten-day waiting period in total or structural demolition. Coordination and communication between your demolition contractor and with his on-site supervisor is critical. We recommend that a final review of the project plan be completed on the first day of the job. Demand that your demolition contractor work in coordination with local landfills or recycling centers to dispose of onsite materials properly. Verify that your contractor complies with mandated resource recovery provisions for disposed project materials.

Table 1. Sequence of Demolition Activity

Demolition Activity Sequence	General Description
Disconnection of services	Shutoff of Electricity, Gas, water etc
Inventory of Hazardous wastes	e.g. Asbestos etc.
Removal of Abandoned Furniture/Equipment	e.g. Furniture/white Goods
Removal of Asbestos/Hazardous Materials	e.g. Application of H&S Procedures
Removal of Fixtures	e.g. Fitted Presses etc.
Removal of Timber	e.g. Removal of Floors, Trusses, Rafters
Demolition of structure shell	Manual or Mechanical Demolition
Source segregation of Material Fractions	Separation into Designated Material Fractions
Transport of Material from site to Treatment Facilities	e.g. C&D waste Recycling Facility
Transport of Material from site to controlled disposal sites	e.g. Inertised Hazardous Landfill site
Site preparation/Restoration	e.g. Hard standing, Landscaping

PROCEDURE FOR DEMOLITION AND REMOVAL OF BUILDINGS
INSPECTION DEPARTMENT
734-466-2580

1) Demolition Permit application must be completed and filed with this office. No accessory buildings may be left on the property without an approval from the Zoning Board of Appeals.
2) With the application, **submit** written releases from Detroit Edison, Consumers Power, the Telephone Company, the Cable Company and the City Water Department.
3) A Plumbing Permit for inspection of cap-off water and sewer, or inspection of wells, septic tanks or cisterns are required.

Minimum Plumbing Permit fee is charged. (Note: a licensed plumber is not required for purpose of this permit). All building demolition fees are based upon cubic feet.

RELEASES AND INSPECTION

Note: Following are requirements for abandoning sewer and water facilities:

a) Contact Miss Dig and then the City Inspection Dept. (Plumbing) 734-466-2580 to arrange for inspection of the work as it is being completed. Note: The sewer and water services are to be abandoned properly **prior** to the building demolition.
b) Sewer leads shall be disconnected and capped at the property line and left open for inspection by the Plumbing Inspector.
c) Water service shall be disconnected on the building side of the stop box, crimped and left open for inspection by the Water Department (for the location of the stop box and inspection of the disconnect, please call 734-466-2633).
d) Existing septic tanks and cisterns must be disconnected, pumped, crushed and filled with sand. A Well Permit from the Stateis required to abandon any wells. (done by a licensed well driller)

INSPECTION

An **open hole** in section from the Inspection Department is required 734-466-2580.The permit holder shall notify the Inspection Department 734-466-2580 to schedule a final inspection when the demolition has been completed, the debris removed and the property has been graded and filled to established street grades.

DEPARTMENT OF PUBLIC WORKS – ENGINEERING DIVISION
734-466-2571

A Demolition Permit for work in the City right-of-way is required from this office. A minimum 35,000 cash deposit (refundable) as well as a 1,000 processing fee is required for the abandonment of utilities, grading or other operations in the public right-of-way.

IN THE RIGHT-OF-WAY:

Any sidewalk damaged as a result of the demolition process will be replaced at permit holder’s expense. Existing sidewalks in the right-of-way cannot be removed without written consent of the Engineering Division.

SOIL EROSION

A soil erosion permit may be required, please check with the Engineering Division at 734-466-2571.

FINAL INSPECTION

The permit holder shall notify the Engineering Division 734-466-2571 when the demolition has been completed. Upon release of the Building Department Permit and satisfactory restoration of the street right-of-way or easement area, the cash deposit will be returned to the permit holder. Further, the entire site will have to be top soiled and seeded with vegetative growth, if a new permit to put a new structure has not been obtained.

In this project I am using Ansys and FEA software draft out building and for finding different loads and stress involved in building for drilling size of hole and placement of explosive in dill to demolition of building.

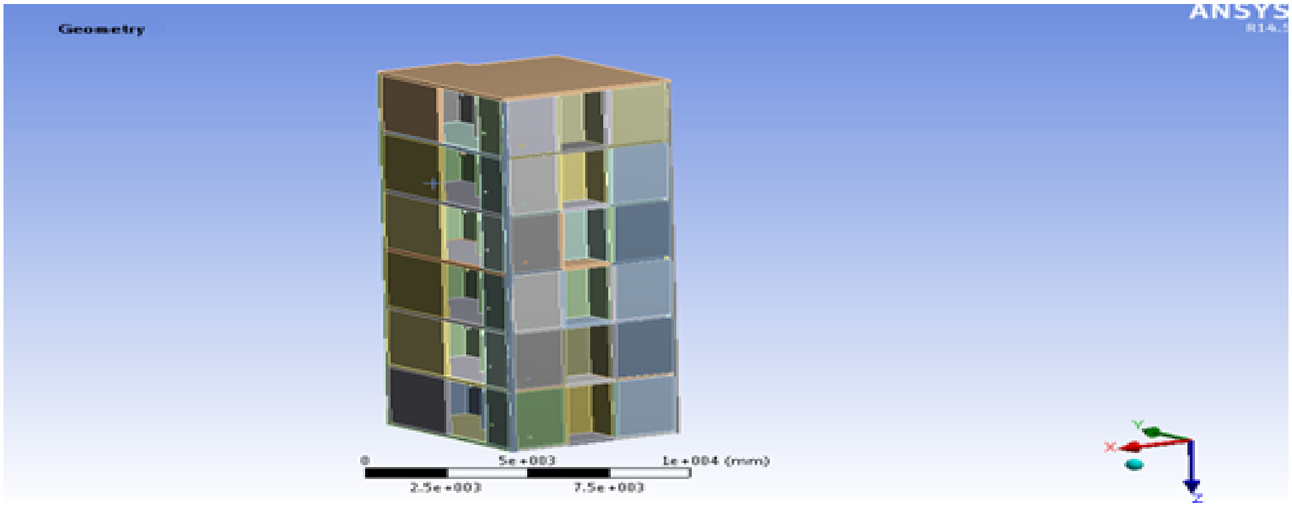


Fig. 1 Geometry of building

Tab2 .Material properties (concrete 35 MPA)

Properties of Outline Row 3: CONC-35MPA

	A	B	C
1	Property	Value	Unit
2	Density	2314	kg m^-3
3	Specific Heat	654	J kg^-1 C^-1
4	RHT Concrete Strength		
5	Use cap on Elastic Surface	Yes	
6	Compressive Strength fc	3.5E+07	Pa
7	Tensile Strength ft/fc	0.1	
8	Shear Strength fs/fc	0.18	
9	Intact Failure Surface Constant A	1.6	
10	Intact Failure Surface Exponent n	0.61	
11	Tension/Compression Meridian Ratio Q2.0	0.6805	
12	Brittle to Ductile Transition BQ	0.0105	
13	Hardening Slope	2	
14	Elastic Strength/ft	0.7	
15	Elastic Strength/fc	0.53	
16	Fracture Strength Constant B	1.6	
17	Fracture Strength Exponent m	0.61	
18	Compressive Strain Rate Exponent α	0.032	
19	Tensile Strain Rate Exponent δ	0.036	
20	Maximum Fracture Strength Ratio SFMAX	1E+20	
21	Damage Constant D1	0.04	
22	Damage Constant D2	1	
23	Minimum Strain to Failure	0.01	
24	Residual Shear Modulus Fraction	0.13	
25	~~Bulk Modulus~~	3.527E+10	Pa
26	Shear Modulus	1.67E+10	Pa

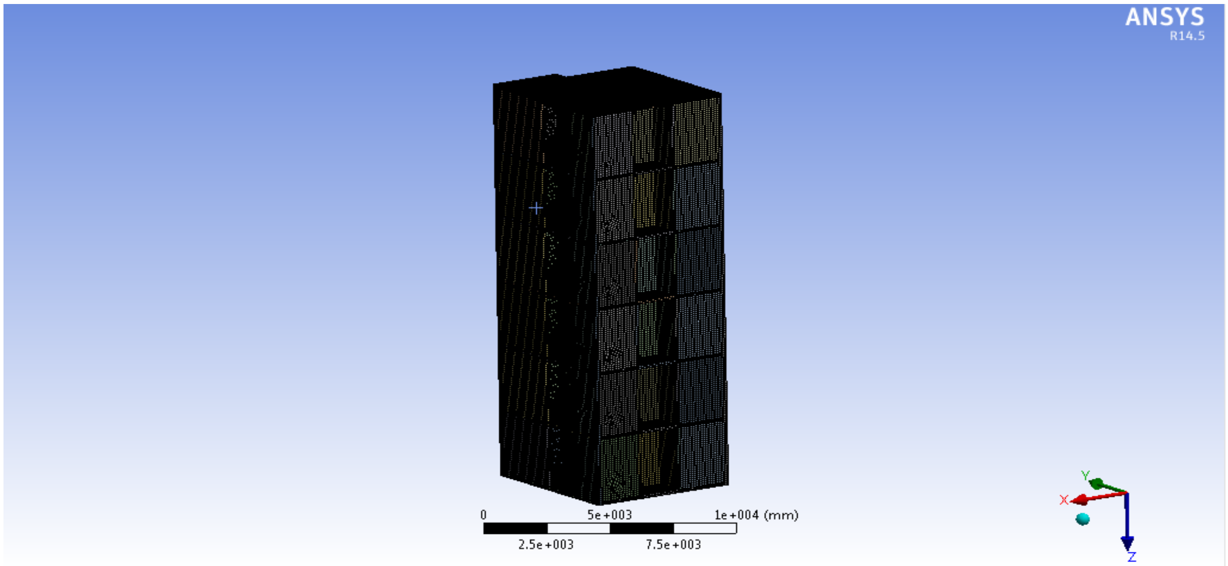


Fig.3 Meshed Model

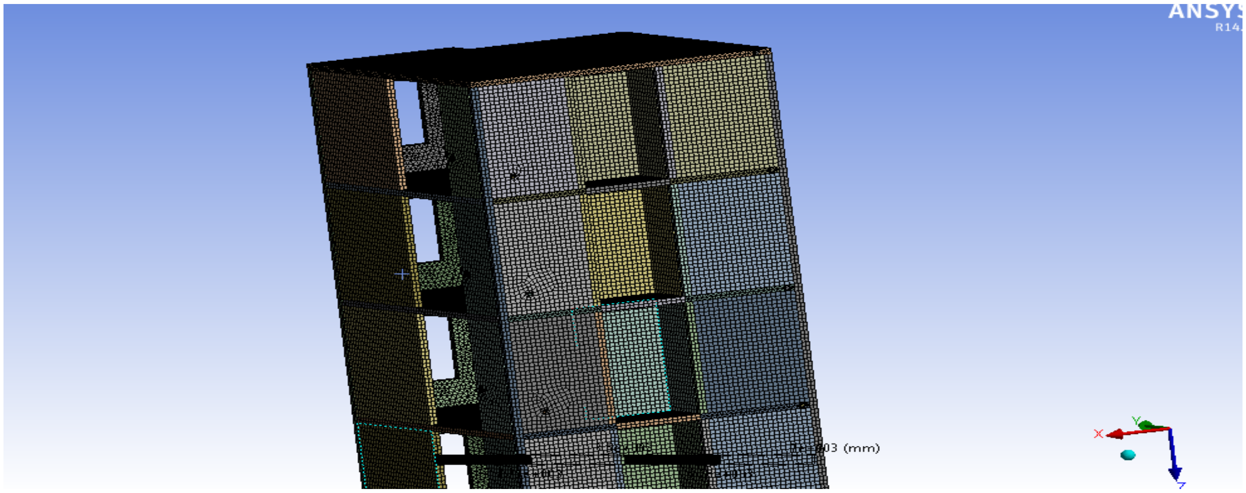


Fig.4 Shape of element: - hexagonal

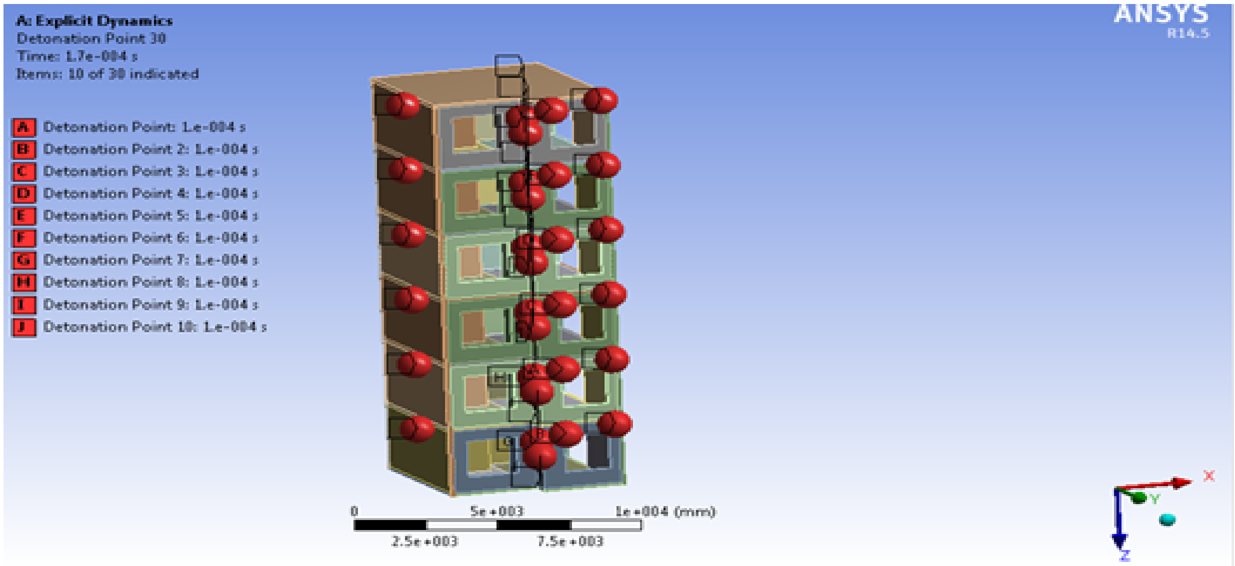


Fig.5 Boundary Conditions

Tab no 3. Material Properties of Explosive PETN 1.77

Table of Properties Row 3: Explosive JWL

	A	B	C	D	E	F	G	H
1	Parameter A (Pa)	Parameter B (Pa)	Parameter R1	Parameter R2	Parameter W	C-J Detonation Velocity (m s^-1)	C-J Energy / unit mass (J kg^-1)	C-J Pressure (Pa)
2	6.1705E+11	1.6926E+10	4.4	1.2	0.25	8300	5.706E+06	3.35E+10

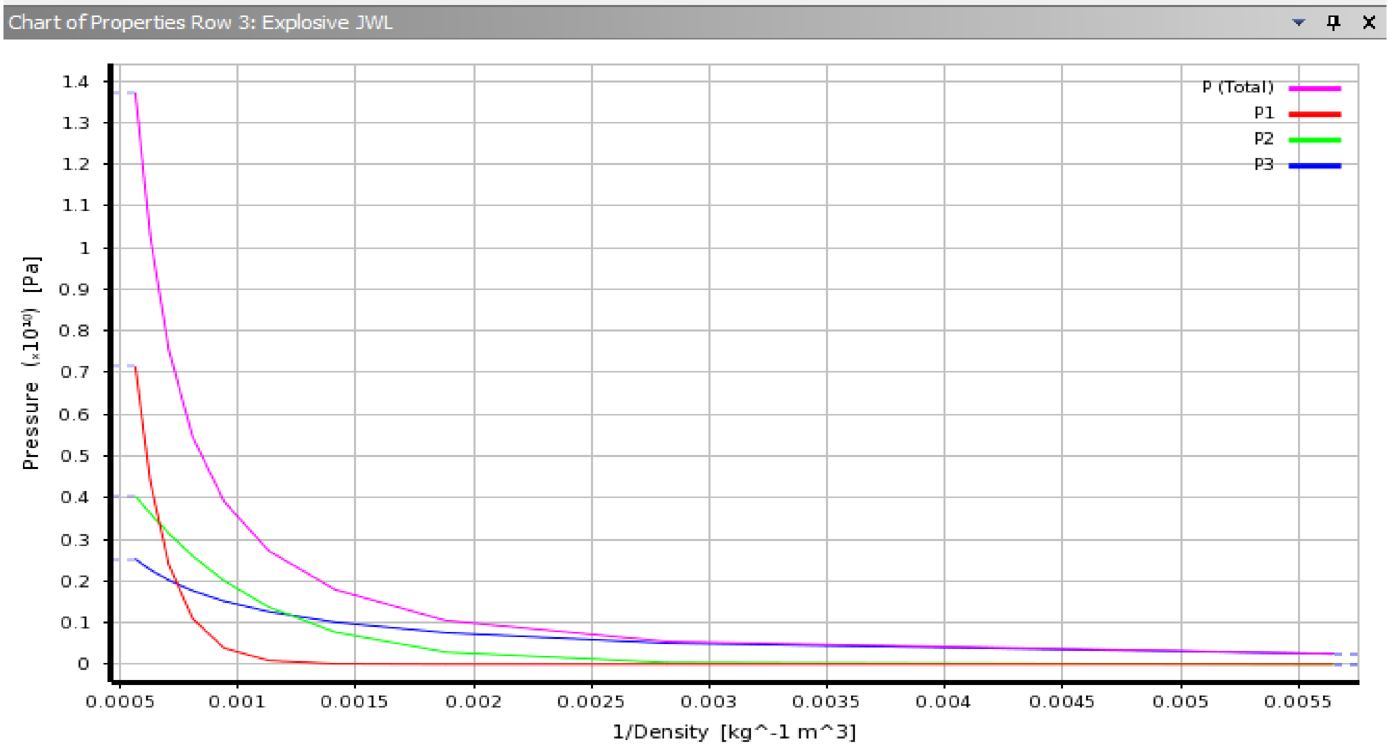


Fig.7 Graph of material properties of explosive PETN 1.77

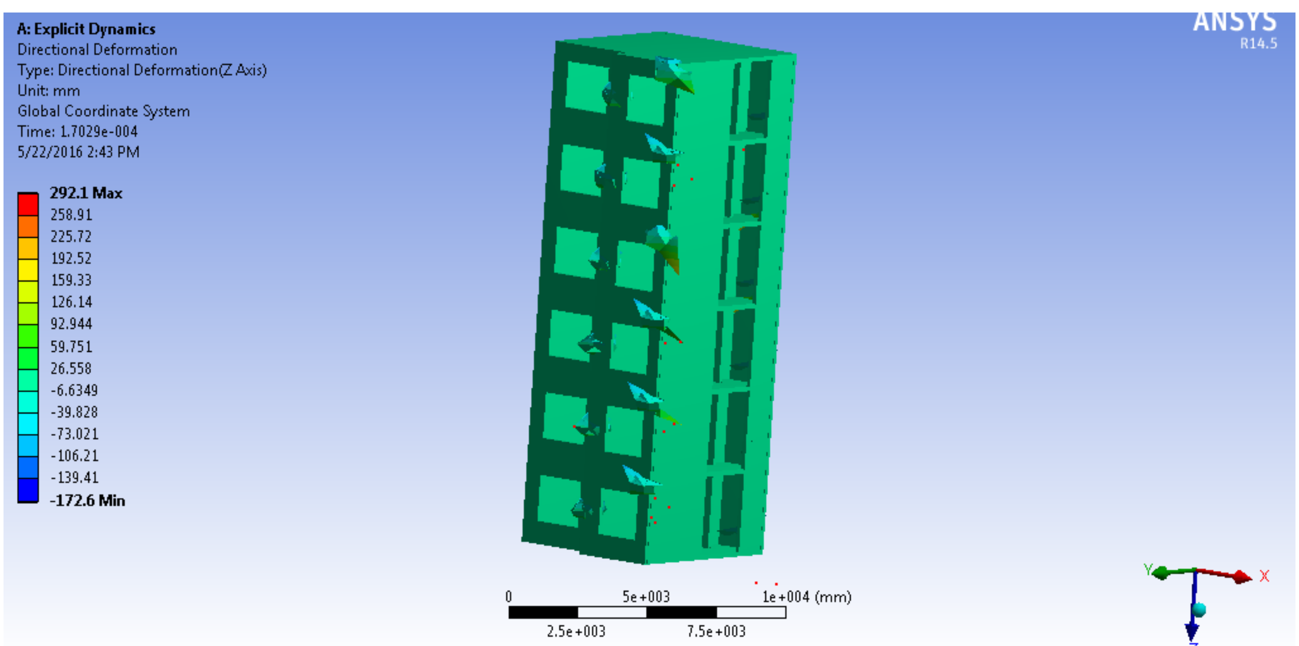


Fig. 8 Directional Deformation

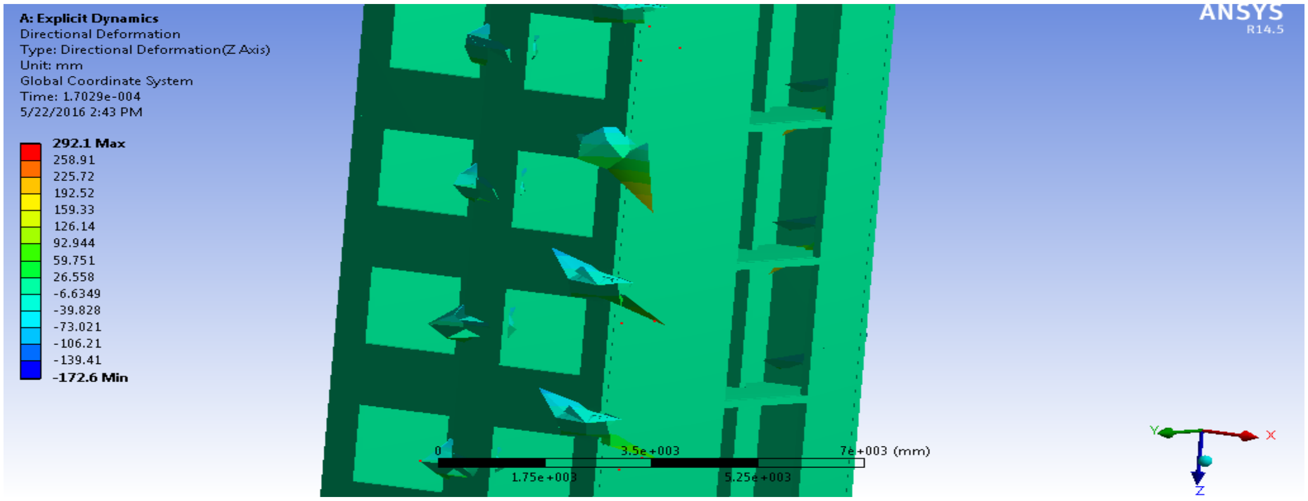


Fig. 9 Closed view of Directional Deformation

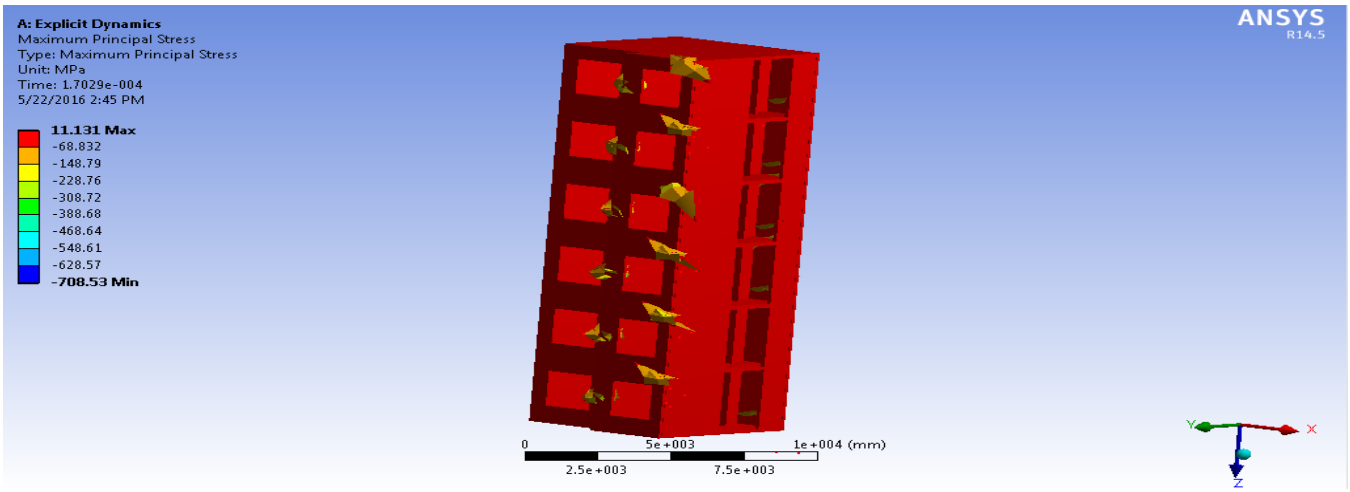


Fig.10 Maximum Principal Stress

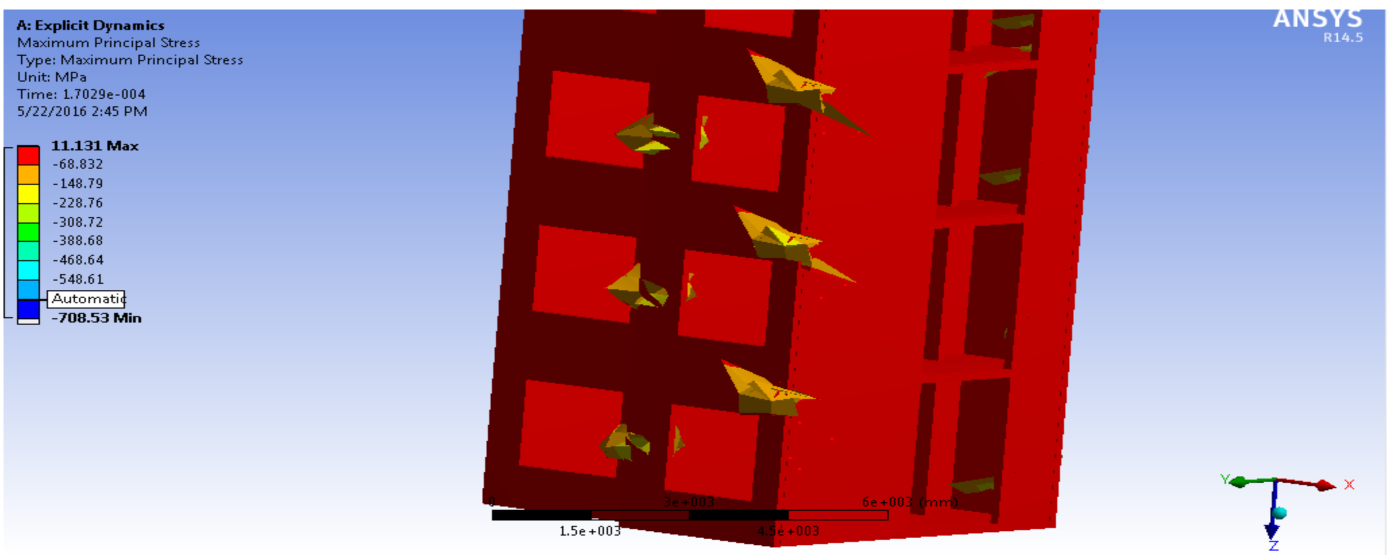


Fig.11 Maximum Principal Stress

Tab no.4 Material Properties of Explosive PETN 0.88

Table of Properties Row 3: Explosive JWL

	A	B	C	D	E	F	G	H
1	Parameter A (Pa)	Parameter B (Pa)	Parameter R1	Parameter R2	Parameter W	C-J Detonation Velocity (m s^-1)	C-J Energy / unit mass (J kg^-1)	C-J Pressure (Pa)
2	3.4862E+11	1.1288E+10	7	2	0.24	5170	5.71E+06	6.2E+09

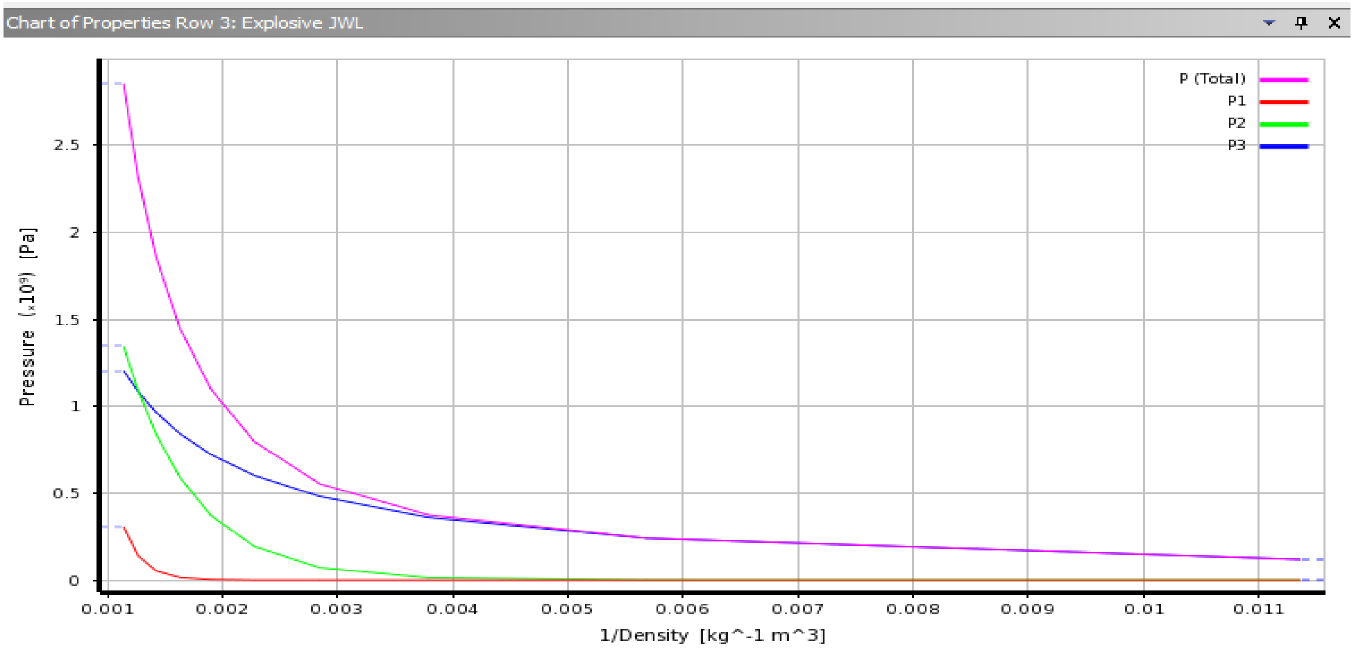


Fig.12 Graph of material properties of explosive PETN 0.88

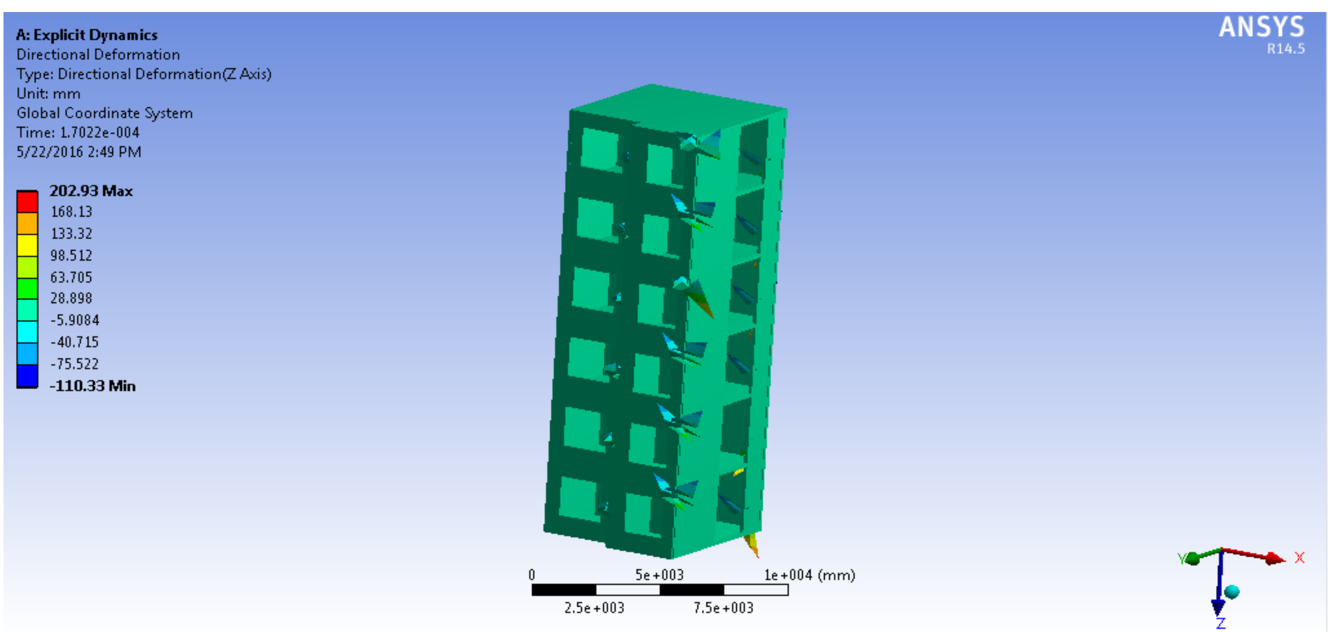


Fig.13 Directional Deformation

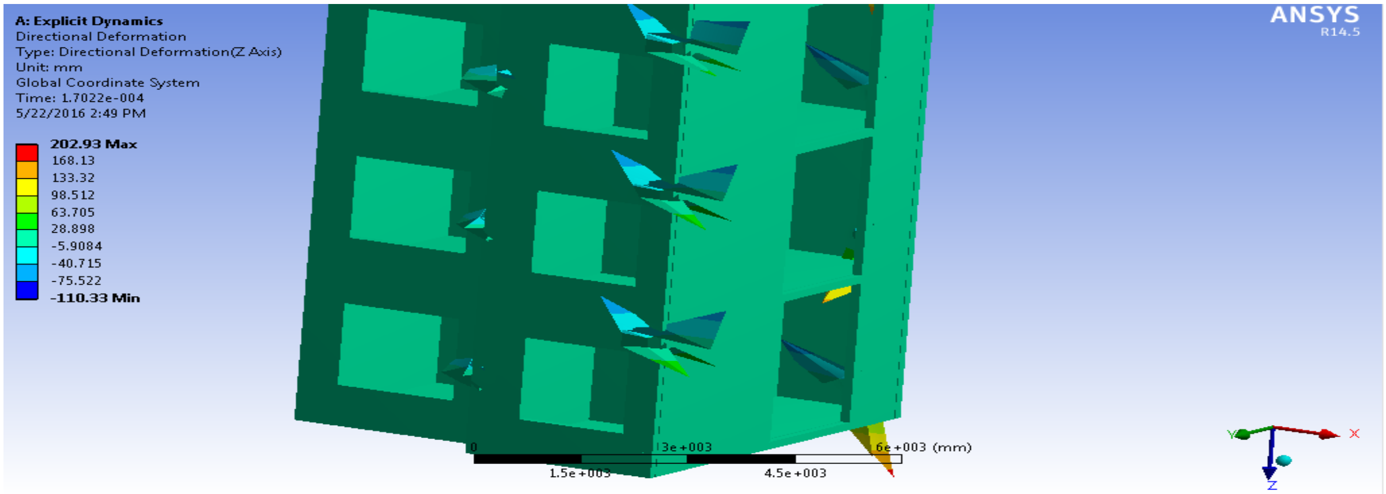


Fig.14 Closed view of Directional Deformation

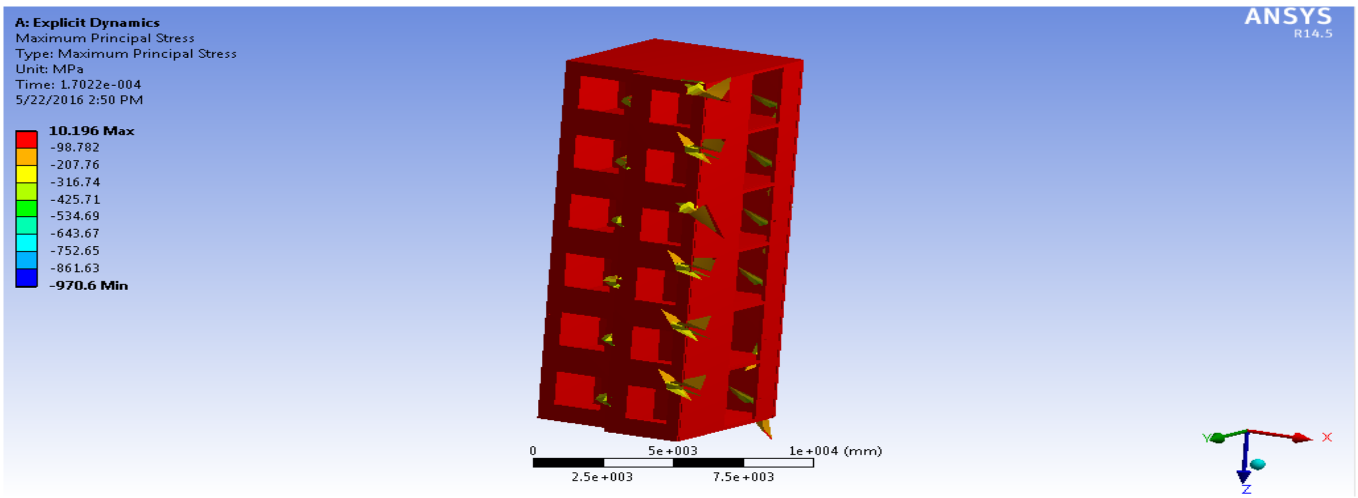


Fig.15 Maximum Principal Stress

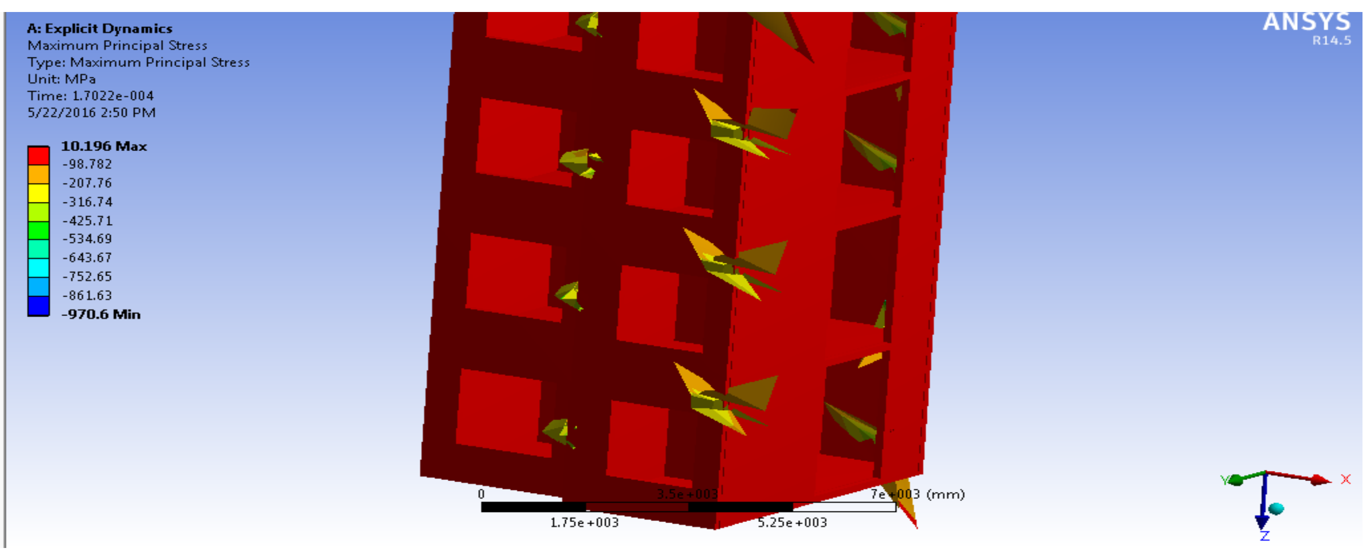


Fig.16 Closed view of Maximum Principal Stress

Tab no.5 Material Properties of Explosive PETN 1.26

Table of Properties Row 3: Explosive JWL

	A	B	C	D	E	F	G	H	
1	Parameter A (Pa)	Parameter B (Pa)	Parameter R1	Parameter R2	Parameter W	C-J Detonation Velocity (m s^-1)	C-J Energy / unit mass (J kg^-1)	C-J Pressure (Pa)	B
2	5.731E+11	2.016E+10	6	1.8	0.28	6540	5.706E+06	1.4E+10	0

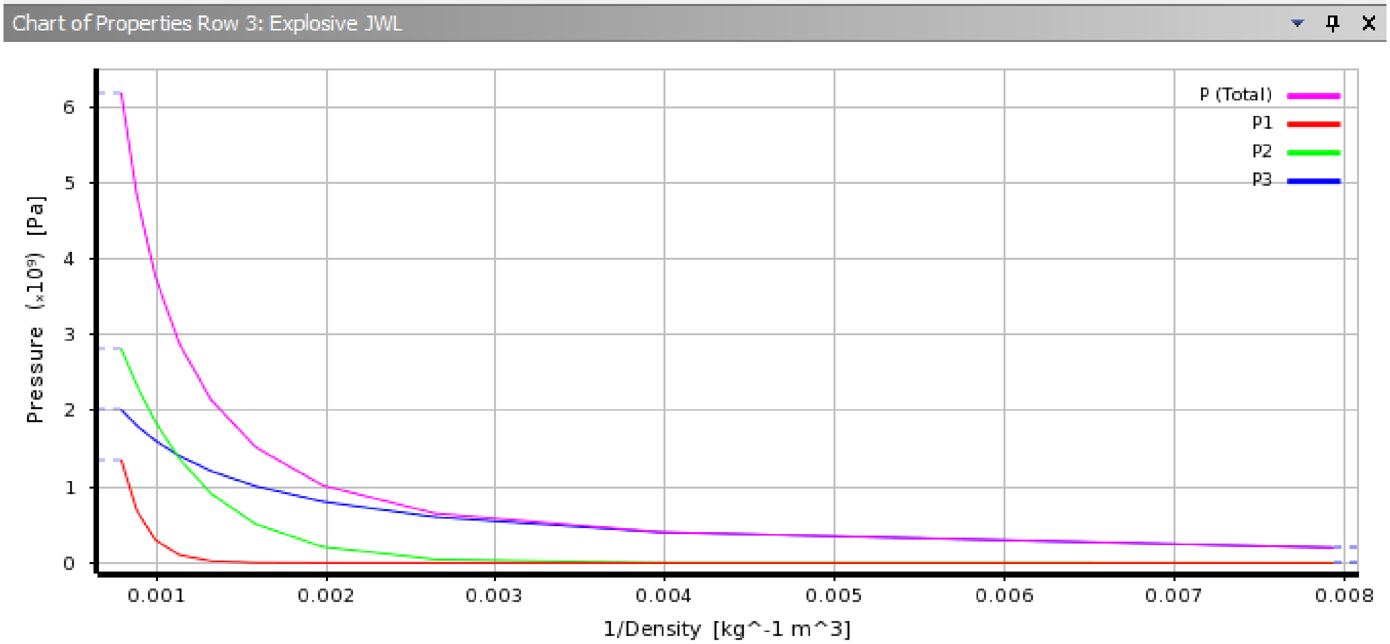


Fig.17 Graph of material properties of explosive PETN 1.44

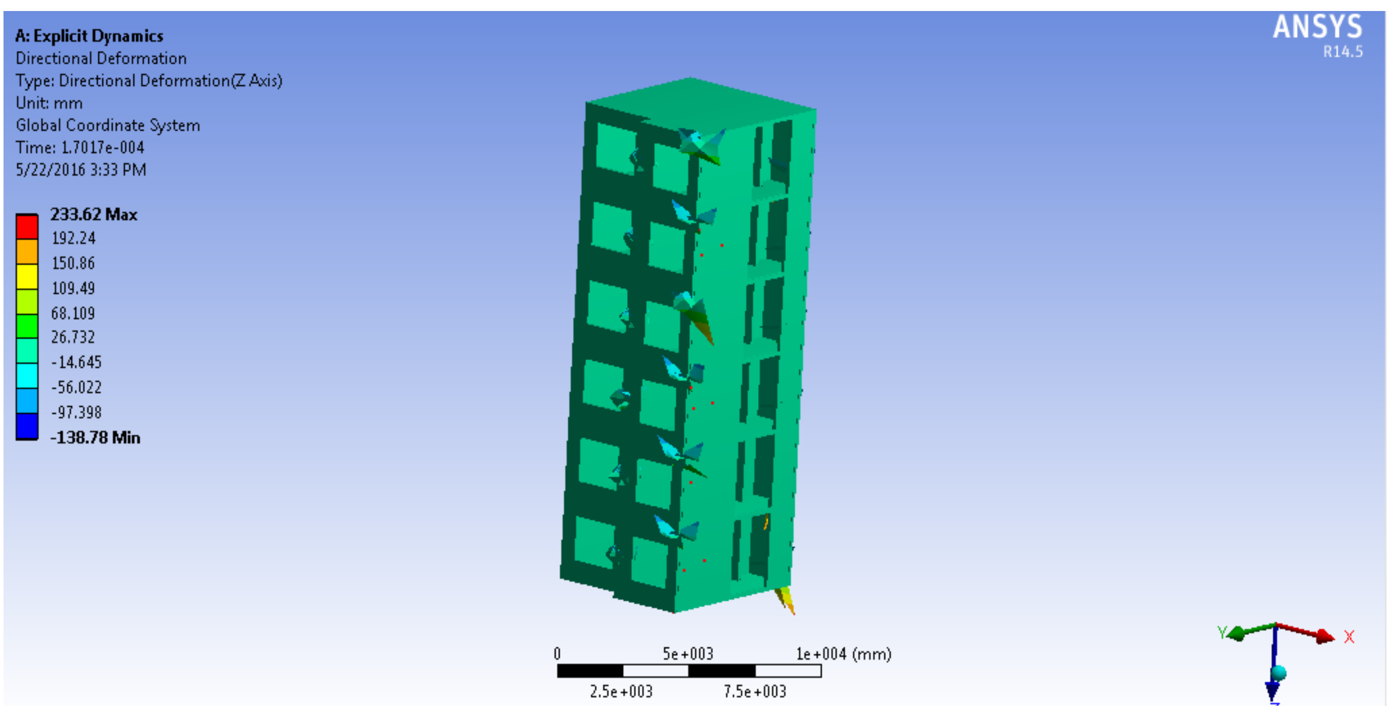


Fig.18 Directional Deformation

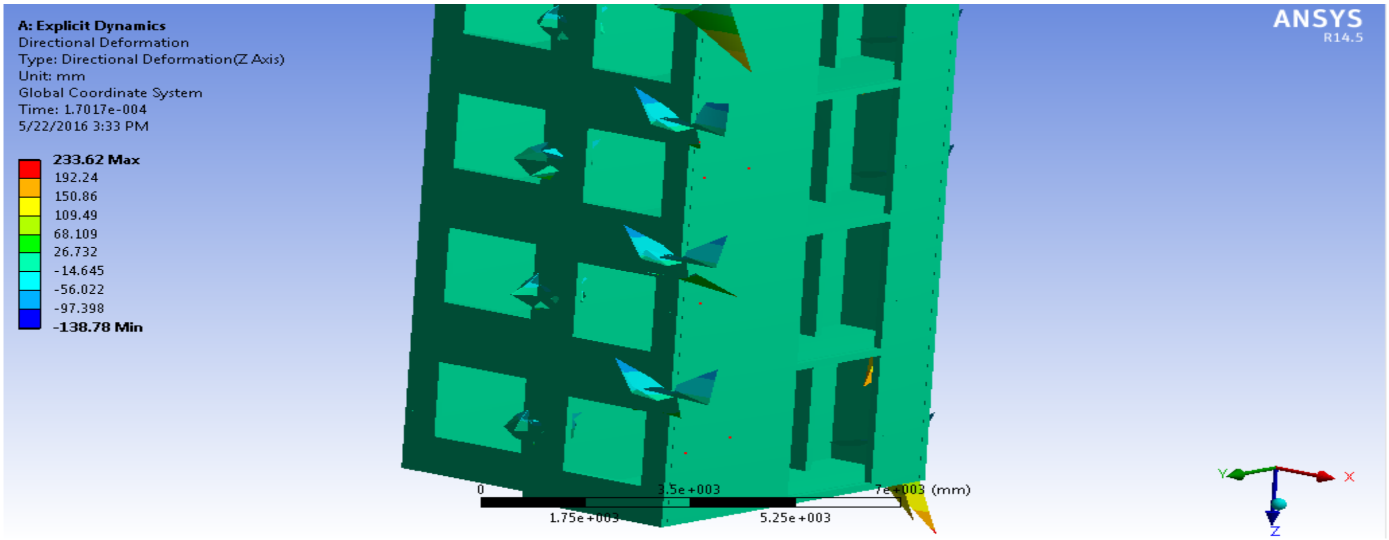


Fig.19 Closed view Directional Deformation

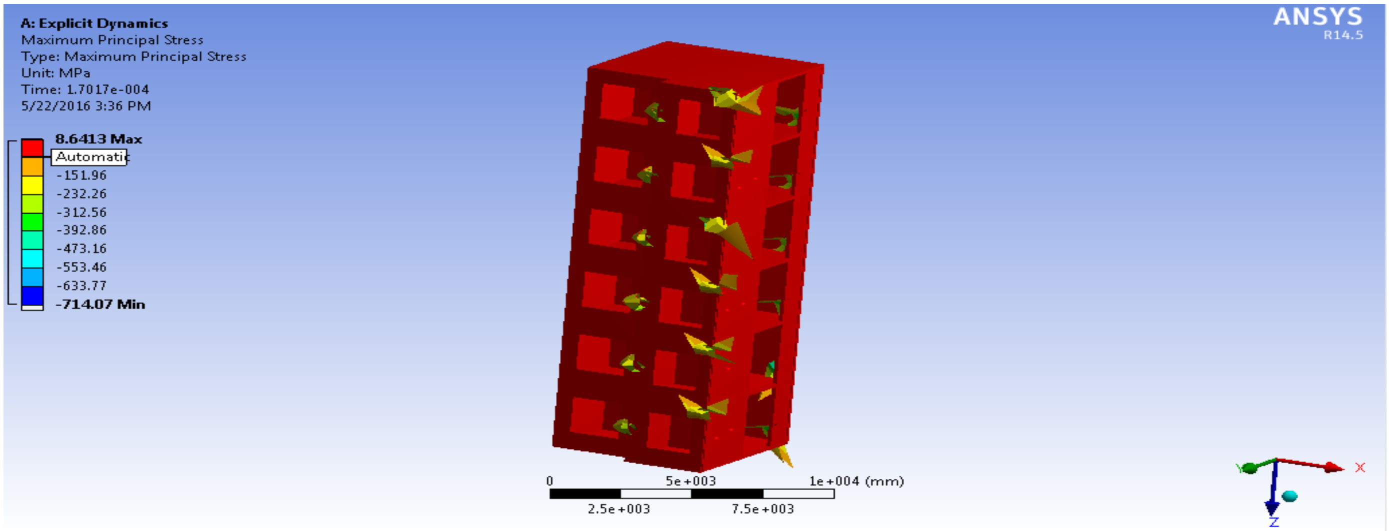


Fig.20 Maximum Principal Stress

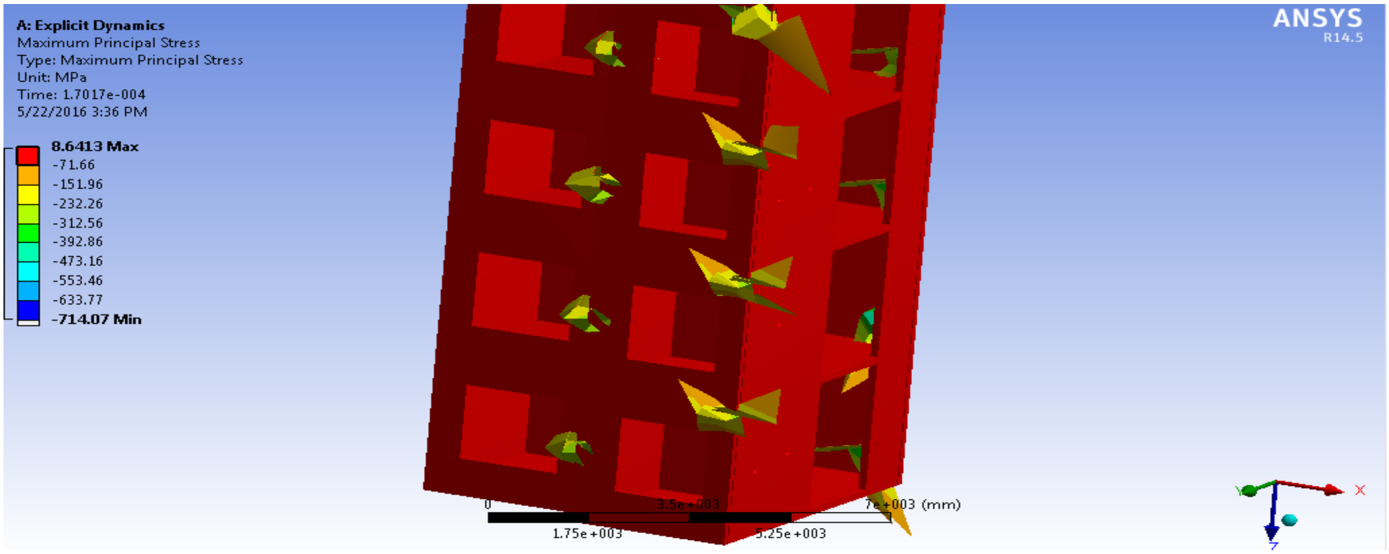


Fig.21 Closed view of Maximum Principal Stress

VI. OBSERVATION TABLE AND RESULT

Tab no.6 deformation and max. Principle stress

Explosive Type	Deformati on in mm	Max. principle stress in MPa
PETN 1.77	292.2	11.131
PETN 0.88	202.93	10.196
PETN 1.26	233.62	8.6413

PETN 1.77 is best explosive for our project because it produces more deformation and principals stress then other explosive i.e. PETN 0.88 and PETN 1.26

VII. CONCLUSION

1. The maximum principal stress generated due to PETN 1.77 explosive is 11.131 MPa and maximum directional deformation is 292.2 mm; which is more than PETN 0.88 and PETN 1.26 explosive.
2. The comparison of different parameters gives PETN 1.77 as a best suitable explosive for explosion of building.
3. We can save the time, cost and labour by using explosive demolition technique.

VIII. FUTURE SCOPE

- The current analysis is carried out using ANSYS workbench 14.5.
- The same analysis using same explosive material can be carried out using different FEA explicit software such as RADIOSS, LS-Dyna.
- In future, the process can be optimized by changing the location, size and the quantity of the explosive.
- Due to such optimization process, the cost reduction will takes place in complete process

REFERENCES

[1] Daigoro Isobe and Yutaka Toi, (1998), "Finite element analysis of dynamic collapse behaviors of framed structures considering member fracture" published in journal of computational mechanics, new trends and applications published in Barcelona, Spain.

[2] Petr Kabele, Tomáš Pokorný and Robert Koska (2002), "Finite element analysis of building collapse during demolition" " published in Czech Republic in Czech.

[3] Adrian Simion and Claudiu-Sorin DRAGOMIR,(2012), **"**The Simulation Of An Industrial Building demolition" published in International Journal of Japan Society of Civil Engineers.

[4] Gunther Blankenhom, Steffen Mattern, K Schweizer, (2007), "Controlled Building Collapse Analysis and Validation" published LS-DYNAA nwenderforum, Frankenthal.

[5] M. Baitsch, M. Breidt, M. Ilikkan and D. Hartmann (2006), "Evolutionary Optimization of Strategies for the Demolition of Buildings with Explosive Charges Using Multibody Dynamics", Ruhr.-University of Bochum, Germany puplished in civil – comp press, scotland.

[6] Marin LUPOAE, Carmen BUCUR, (2009),"Use Of Applied Element Method To Simulate The Collapse Of A Building" published in SISOM 2009 and Session of the Commission of Acoustics, Bucharest 28-29 May.

[7] Samia A. Ali, Khaled F. Hussain, and Ahmed M.Sayed, (2011), "Fast Generation Of Demolition Special Effects On 3d Buildings" published in Journal of Engineering Sciences,Assiut University, Vol. 39, No 1, pp. 49-71, January 2011.

[8] Zhen Chen, Ph.D., M.ASCE; Arham B. Abdullah, Ph.D.; Chimay J. Anumba, Ph.D., F.ASCE; and Heng Li, Ph.D., (2013), "ANP Experiment for Demolition Plan Evaluation" published in 2013 American Society of Civil Engineers.

[9] Timothy D. Stark, Ph.D., P.E., F.ASCE, (2013), "Is Construction Blasting Still Abnormally Dangerous?" Published in American Society of Civil Engineers.

[10] John A.Gambatese, P.E., M.ASCE, (2003), "Controlled Concrete Demolition Using Expansive Cracking Agents" published in American Society of Civil Engineers.

[11] A.Plotzitza; T.Rabczuk; and J. Eibl; (2007)"Techniques for Numerical Simulations of Concrete Slabs for Demolishing by Blasting" published in American Society for Civil Engineers

[12] Osama Abudayyeh , AnU Sawhney,Hossam EI-Bibany and David Buchanan, (2009), "Concrete Bridge Demolition Methods And Equipment", published in American Society for Civil Engineers.

[13] M.G.Bhandari, V.K.Kulkarni, R.K.Malviya, (2013), "Building Demolition: Ground to Earth Important as Construction" published in International Journal of

Emerging Technology and Advanced Engineering, Volume 3, Issue 4, April 2013

[14] www.ethika.co.in

[15] http://ascelibrary.org

[16] http://www.sciencedirect.com

[17] http://accessengineeringlibrary.com