JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 5, ISSUE 06, 2018

IMPACT ANALYSIS OF CONVENTIONAL WEAPON LAUNCHED FROM AIRCRAFT ON DIFFERENT METALS & CERAMICS

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ABSTRACT:

the study of rectangular steel plate subjected to blast loading generated by TNT explosive charges and results carried out using LS-DYNA commercial code. Under the blast loading structural material has approved considerable attention in present days due to the effect of various incidence, suchas bomb blast in terroristic attacks & domestic demolition become a concern dueto their increased effect on the lives and properties. Behavior and characteristic ofblast wave generated from the blast was explained initially and the behavior of suchstructures under these loads explained later. Significant amount of strain energyabsorbed by steel & resistance against explosion so used in structural applicationsof aerospace, automotive, and civil engineering. The blast load was simulated usingan Arbitrary LagrangianEulerian (ALE) method, with Fluid Structure Interaction(FSI) among the Eulerian blast and Lagrange target models.

Keywords: Blast, impact, STEEL, FEM, LS-DYNA

INTRODUCTION:

In the engineering blast loading event, explosive products are used in extensive range.In order to select and use the explosive efficiently and safely it is very important toidentify characteristic each explosive. For the describing of blast effect on thestructure, there are two steps essential: The initial one is an investigation of thedynamic load - blast wave generated in the ignition of explosives and the other one isa study of the structure response.Huge amount energy release is nothing but an explosion and differentiated as physical& chemical detonation. Wide-ranging damages to the structure and environmentstakes places when explosives such as TNT and ANFO exploded in order to generatethe blast waves.

Sherif A. Mazek (2017) investigated the‘effect of blast wave on lightweight structure performance’, the aluminum foam (ALF) as core material encased by the two steel plates is used to discuss the impact of blast hazard on lightweight sandwich structure performance. Field blast test is used to validate numerical model of the composite structure under blast effect.As the Armox-500 steel plate is used as a face plate the small maximum displacement is obtained. Lightweight sandwich structure reduces the maximum displacement up to 40%. The ALF has a large amount of strain energy which can absorb the kinetic energy of the blast wave propagation.SajalVerma, Mainak Choudhury (2015) also gave the result on ‘blast resistance design of structure’, that Fibre-Reinforced plastic used in stonework walls were found to be

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perfect in blast resistance, polyurea and Glass Fibre- Reinforced polymer were found to be effective in ending wall fragmentation, polyurea sprays has the ability of channelizing th e load to the frame.Dr. Sudeep Kumar Lahiri, Dr. Lee Ho Providence, RI, USA in 'blast loading due to conventional weapon (CONWEP)' uses 3kg TNT blast case for both solid plate and sandwich structure and they found that, the displacements of the solid plate centre from simulations using shell elements and solid elements are almost identical. Less deformation of the bottomplate of the sandwich structure than that ofthesolidplateofequalstructuralmassindicatestheadvantageofthesandwichstructure.Arif S. M. Sohaimi (2016) investigated 'blast wave propagation understructureusingcomputationalfluiddynamics(CFD)'.Heworkedonfreefieldairblastandblastloadingonstructureusing ANSYSFLUENTsoftware.Kathryn Auckland (2013) studied "Deformation of polyurea-coated steelplatesunderlocalizedblastloading".Hemadeexperimentalandnumericalinvestigations to study whether the polyurea-coated plate is incorporate into blastresistantdesigncomparedtobaresteelplateswiththesame arealdensity.SebastianHeimbs,JosefRitzer,andJohannesMarkmillerSebastian Heimbs, Josef Ritzer, and Johannes MarkmillerHave studied "The development of an empirical approach to represent the blast shock wave loading resulting from the launch of a missile from an aircraft" based on an experimental test campaign was presented. Similarities to the blast shock wave of a conventional singular detonation of an explosive charge were highlighted in terms of the possibility to apply the Friedlander curve to approximate the pressure-time response.HrvojeDraganić&DamirVarevacstudied&concluded"Analysisof BlastWaveParametersDependingon AirMeshSize"studiedandconcludedNorecommendationsexistformeshsize selection in blast load numerical simulations since the size of thefinite element strongly depends on the blast scenario. For this reason,the mesh size convergence tests were carried out for ground explosionscenarios.Have studied "The development of an empirical approach to represent the blastshock wave loading resulting from the launch of a missile from an aircraft" basedon an experimental test campaign was presented. Similarities to the blast shockwaveofaconventionalsingulardetonationofanexplosivechargewerehighlightedin termsof thepossibility to apply theFriedlander curveto approximatethepressure-timeresponse. Ngo T, P Mendis, A Gupta, and J Ramsay. In "Blast Loading and BlastEffectson Structures – An Overview." Studied and concluded For high-risksfacilitiessuchaspublicandcommercialtallbuildings,designconsiderationsagainst extreme events (bomb blast, high velocity impact) is very important. It isrecommended that guidelines on abnormal load cases and provisions on progressivecollapse prevention should be included in the current Building Regulations andDesign Standards. Requirements on ductility levels also help improve the buildingperformanceunder severeloadconditions.Despite the fact thatthemagnitudeoftheexplosion andload causesby itcannotbeanticipatedperfectly,efforts canbemadetoreducetheconsequences oftheexplosion. Inthispresent work , a G+4 storey RCC building is subjected to 100Kg,150Kg,200Kgand 250Kg Tri nitro toluene (TNT) blast sources at a distance of 30m,40m and50m from the building is considered for analysis.IS 4991-1968 is used for themanual calculation of blast load and force time history is performed in STAADPro. The parameter like moment on column and shear force and moment on beamarestudied.

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CONVERSIONFACTORSFOREXPLOSIVE:

largescalemassdestructionandyetarecapableofcausingsignificantdamagetolifeandproperty aregenericallyreferredtoasconventionalweapons.Theseweaponscharacteristically contain land mines, non-nuclear bombs and arsenals etc. Thedanger from such weapons is measured by the amount of the discharge, or thecharge mass; and the distance of the detonation from the standoff distance. Theamountchargemassusedinconventional armamentsismeasuredinkilogramsofTNT.

Table1.1Conversionfactorsforexplosives[BlastLoadingonStructurebyH. Draganić, V.Sigmund-2012]

Explosive	SpecificEnergy	TNT Equivalent
RDX	5359	1,185
HMX	5679	1,256
Nitroglycerine	6699	1,479
TNT	4519	1000
60%Nitro-glycerine dynamite	2710	0600
Semtex	5659	1249
C4	6061	1339

1.4.1 PRESSURE

By definition, pressure is normal force that acts on unit area.Due to the motion ofmolecules within a medium and their contact with their surroundings there isincrementinthepressure.Theychangethepath&impartmomentumtothewallswhen the molecules of a medium interact with their surroundings such as the wall ofacontainer.

We may consider two kinds of pressure, namely static and dynamic pressureundertheflowconditionsthatareexperiencedinablast situation.

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STATICPRESSURE

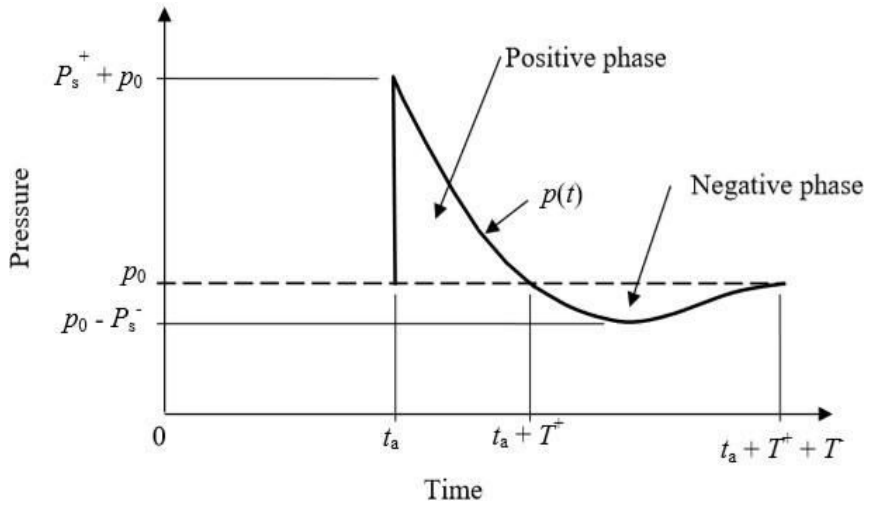

Figure2.1pressure–timecurveforanexplosiveblastwave[Bakeretal.,1983].

METHODOLOGY:

Blastsafetyofthestructurewillgenerallyhaveatleastoneofthefollowingaims:

1. Todecreasethepermanentdeformationi.e.openingofthestructure.
2. Toreducethetransientdeformation.

Toreducerupturei.e.sliding(In-planeshear),tearing(outofplaneshear).

WEIGHTOFEXPLOSIVE

The charge mass used in conventional weapons is taken in kilograms ofTrinitrotoluene. Blast characteristics of TNT are resembled to most of thesolidtypeexplosiveshenceTNTwasselected.AnequivalentTNT weightiscomputed,

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$$W_e = W_{exp} \frac{(H_{exp})^d}{(H_{TNT})^d} \quad \text{.....3.1}$$

Where, W_e is the equivalent weight of TNT [kg],

W_{exp} is the actual weight of explosive [kg],

(H_{exp}) is actual heat of detonation of the explosive |MJ/kg|,

$(H_{TNT})^d$ is the heat of detonation of the TNT [MJ/kg]

Table3.1Indicativevalues ofheatofdetonationofcommonexplosives

Nameofexplosive	Heatofdetonation [MJ/kg]
TNT	4.1–4.55
C4	5.8599
RDX	5.1–6.2
PENT	6.7
NITROGLYCERIN	6.3
NITROMETHANE	6.4

Scaled distance

The distance of the detonation point from the structure is one of the mostcrucial parameters for blast loading analysis. The effect of distance on theblast characteristics can be considered by the introduction of scaling laws.According to Hopkinson-Cranz law, a dimensional scaled distance isintroducedasdescribedby,

$$Z = \frac{R}{\sqrt[3]{Z}} \quad \text{.....(3.2)}$$

Where, R is the distance between the detonation source & point of interest

[m] W is explosive weight [kg].

MODELLIG:

This chapter deals with the designing and meshing of the model.

As explained in earlier chapter both designing and meshing is done in the LS- DYNA software.

Table5.1Keywords usedinLS-DYNA

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Keyword	Description
*ALE	Offerawayofdefininginputdatapertainingtothe ArbitraryLagrangianEuleriancapability
*BOUNDARY	Defineprescribedboundarytothe model
*CONSTRAINED	Toconstrainswithinthestructure andstructuralparts
*CONTROL	Todefine the terminationtime ofanalysis
*DATABASE	Todefinethe database foroutputfiles
*MAT	Itcontains materialpropertiesforthe model
*NODE	Itconsistsofnodedataofthemodel
*PART	Entiredata ofthe modelinthe formofID's
*SET	Setdata types(i.e.,nodes,beams,shellsetc.)
*SECTION	Todefinethe section propertiesofthe model

LS-DYNACARDSFOREXPLOSIVE&AIR[mm,kg,ms]

Table5.2Explosive &AirLS-DYNAcards

*MAT_HIGH_EXPLOSIVE_BURN(TNT)						
RO	D	PCJ	BETA	K	G	SIGY
1.6E-6	6940	21	0.00	0.00	0.00	0.00
*EOS_JWL(TNT)						
A	B	R1	R2	OMEG	E0	V0
598.15	13.7500	4.5000	1.5000	0.3000	8.699998	1.000
*MAT_NULL(air)						
RO	PC	MU	TEROD	CEROD	YM	PR
1.226E-6	0.00	0.00	0.00	0.00	0.00	0.00
*EOS_LINEARPOLYNOMIAL(air)						

C0	C1	C2	C3	C4	C5	C6	E0	V0

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0.0 0	0.00	0.00	0.00	0.400	0.400	0.000	0.000	1.00 0

5.1.1 MATERIAL:

5.1.1.1 STEEL:

- Steeliscombinationof ironand carbon.
- Steelisductilematerialandcanabsorbsignificantamountofstrainenergy.
- Itisamainconstituentusedinbuildings,infrastructure,tools,ships,automobiles ,machinesandweaponsdueitshightensilestrengthandlowcost.

DIAMENSION:

Steelplateortarget is0.08 (m)by0.1(m)withthethicknessof0.005 (m)asshown infigure5.1.

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Steelplateortarget is0.08 (m)by0.1(m)withthethicknessof0.005(m)asshown infigure5.1.

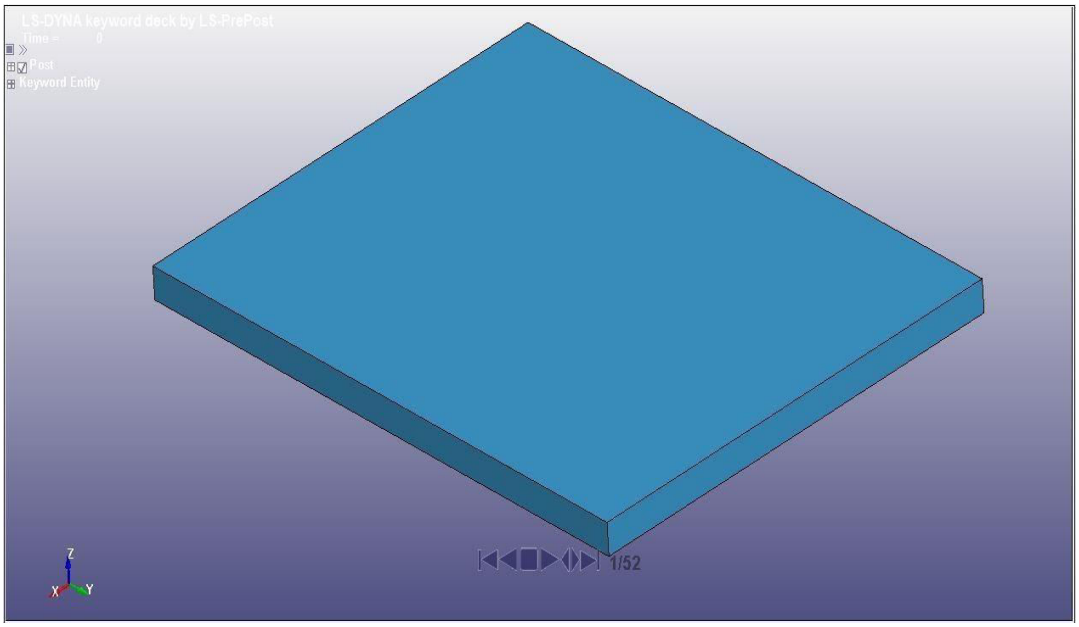

Figure5.1steelplate model

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STEELPROPERTIES:

Table5.3Materialpropertiesofsteel

PROPERTY	
Density	7870 Kg/m^3
Poisson's ratio	0.29
Modulusofelasticity	205GPa
Modulusofrigidity	79.3GPa
Yieldstress	250MPa

5.1.1.1 TRINITROTOLUENE(TNT):

- Formilitary,industrialandminingapplication

TNTisthemostcommonlyusedexplosives.

Table5.4MaterialProperties ofTNT

Properties	
DensityofTNT	1601Kg/m^3
DetonationVelocity	6930m/s
HeatofDetonation	4184KJ/Kg

Result & Discussion

6.1 PRESSUREVARIATIONINTHESTRUCTURE:

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Detonation of an explosive involves chemical reactions which causes rapid heatingand expansion of the detonated products. This rapid expansion causessuddencompressionoftheneighbouringmediumthatleadstotheformationofblastwavea nd propagates away from the source with high velocity. The state of the medium,described by its pressure, density and velocity are discontinuous across the wavefront.

The hot gases formed swell spherically in order to occupy the space available thatleads to wave type propagation during burst. Along with the produced gases, theairaroundtheblastalsoswellsanditsmoleculescrash,resultinginblast wave.Duringthe detonation process one-third of the chemical energy available is released and theresidual two-thirds is released more gradually as the detonation products mix withairandburn.

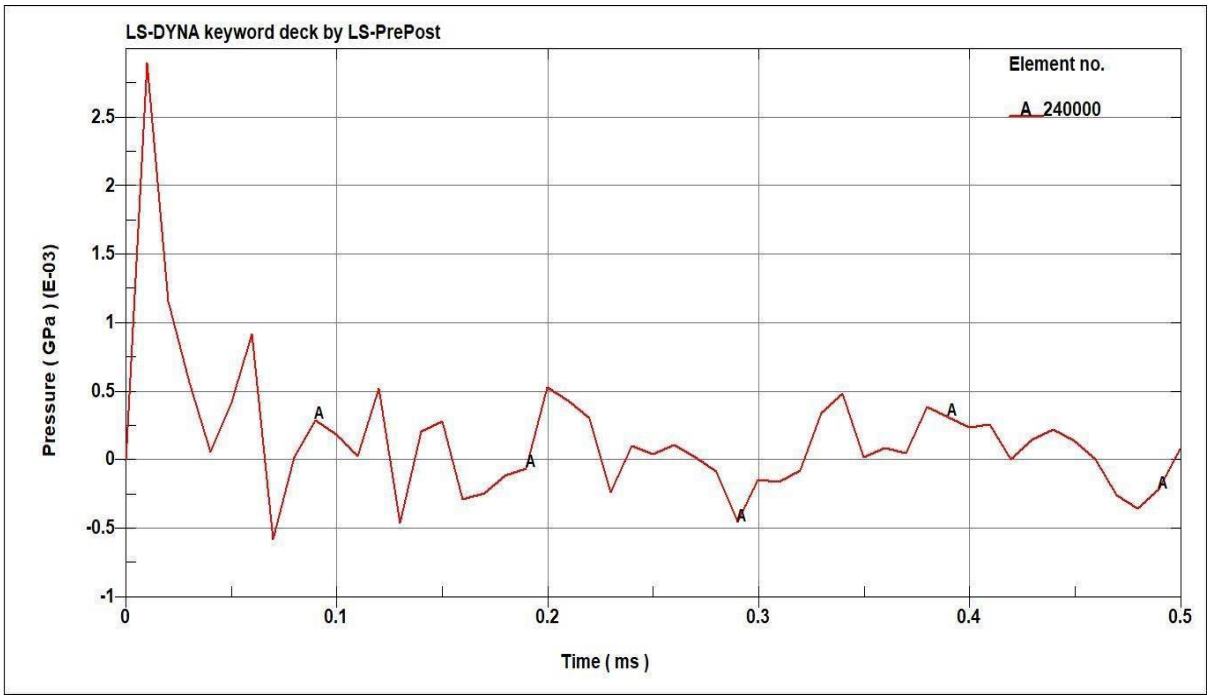

Figure6.1PressurevsTimegraph

Initiallythepressurearoundthestructureorobjectisidenticaltotheatmosphericpressure i.e.1 atm.andwhenthewavefrontreachestothesurfaceatthatpointitexperiencesaninstantaneous increase in a peak pressure to 2.9 MPa at the advent time of 0.00996millisecond.Thereisadeclineinpeakpressureaswellasthevelocityofthewavewithincreasin gdistancefromthedetonationcentre.Thepressuredecreaseswith anexponential rate until it reaches the ambient pressure. After the positive phase of thepressure-time diagram,

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thepressurebecomes smaller (referred to as negative peakpressure) than the ambient value, andfinallyyieldstoambientpressure.Thenegativephaseislongerthanthepositiveone,itsminimumpressurevalueis0.579MPa.Figure 6.2showsthepressurevariationintheplateatdifferenttimeinterval.

Pressurevariationatdifferenttimeinterval

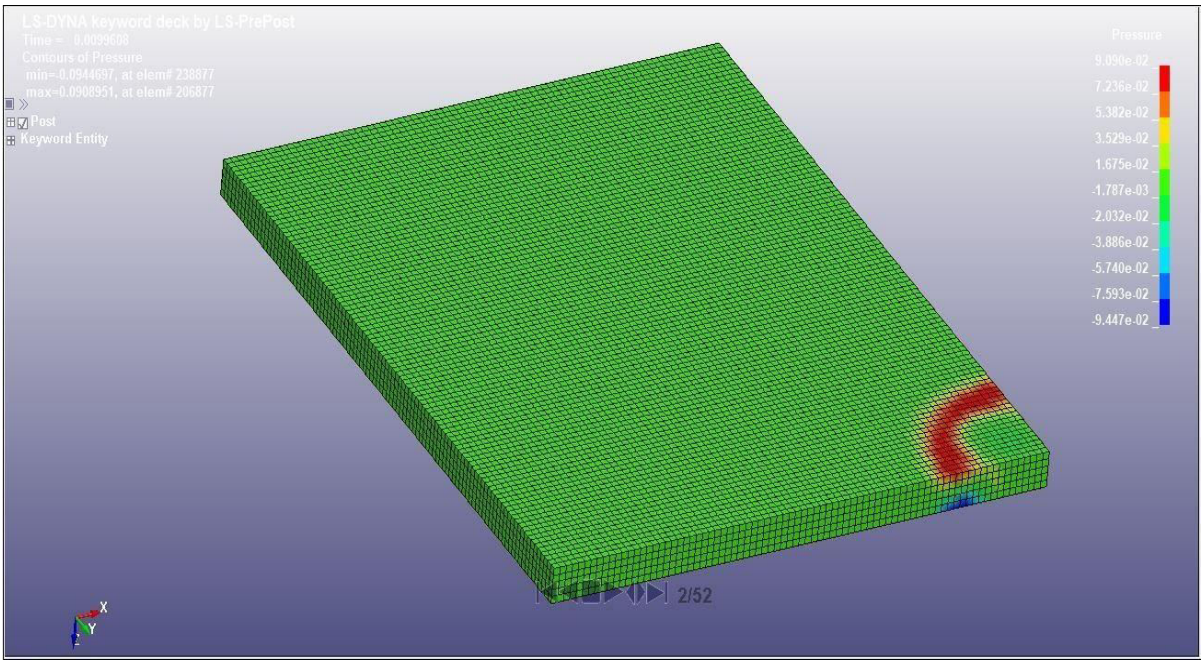

Figure6.2(a)Pressurevariationat0.01millisecond

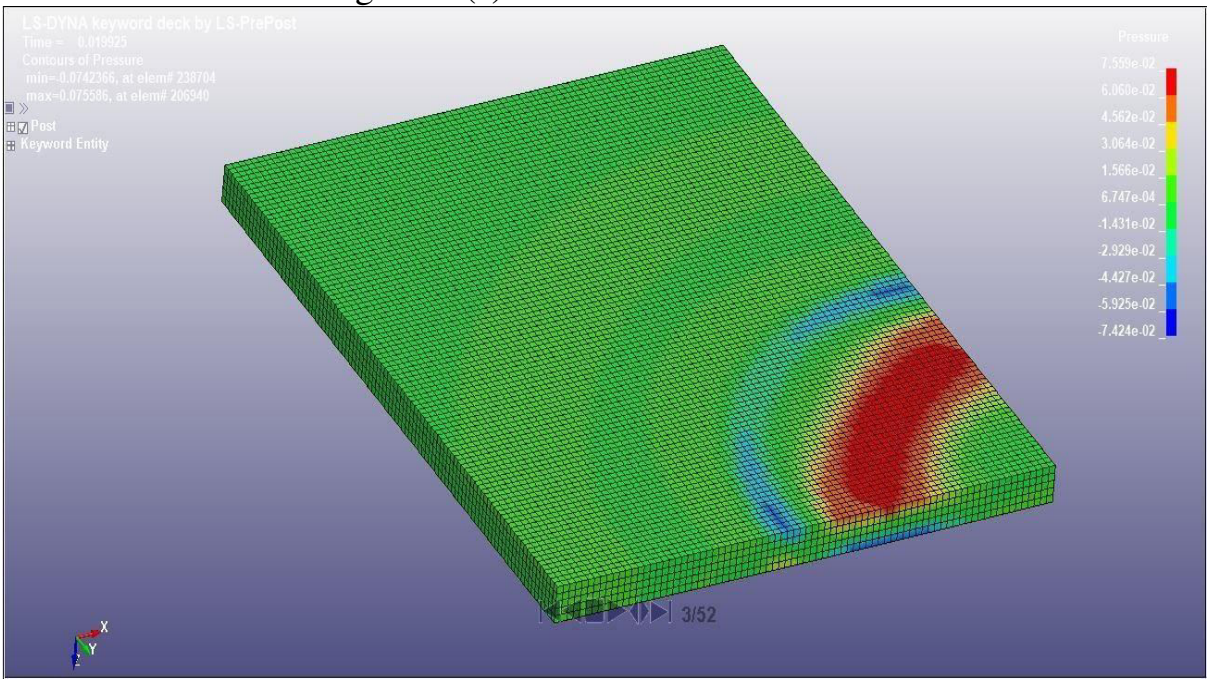

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Figure6.2(b)Pressurevariationat0.02millisecond

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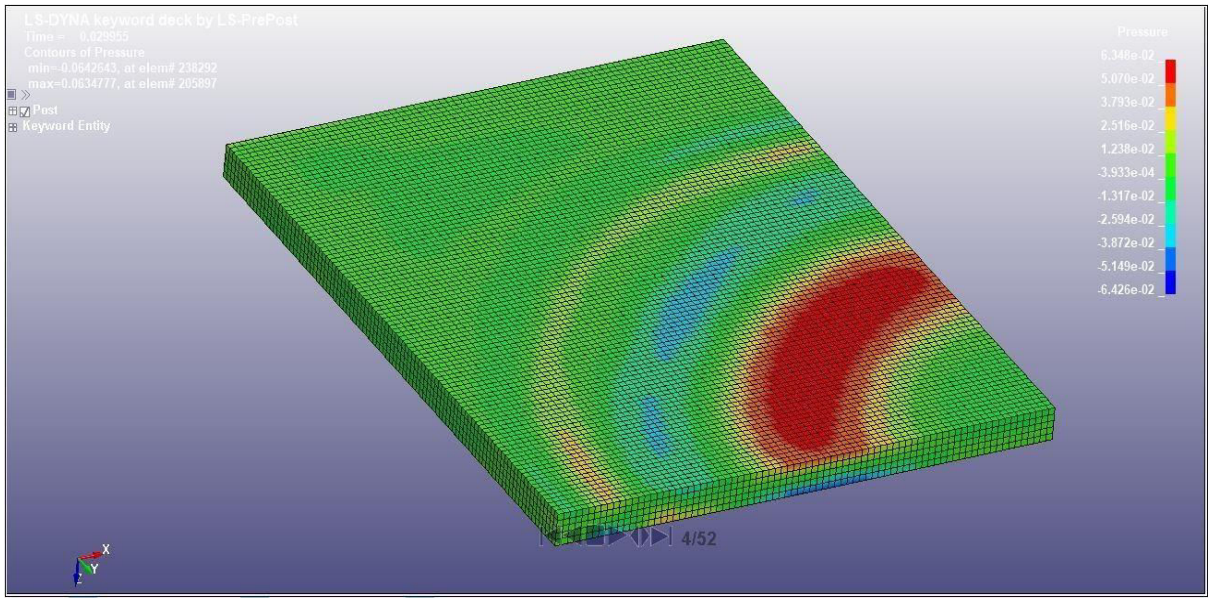

Figure6.2(c)Pressurevariationat0.03millisecond

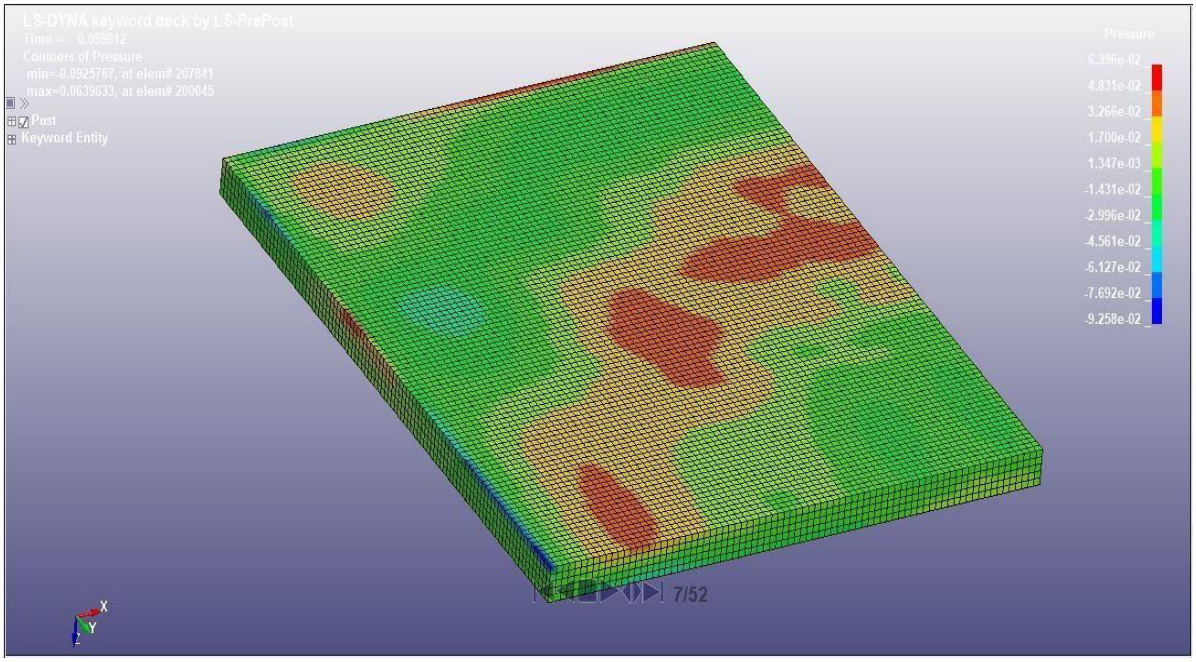

Figure6.2(d)Pressurevariationat0.06millisecond

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PRESSUREVARIATIONATDIFFERENTLOCATION:

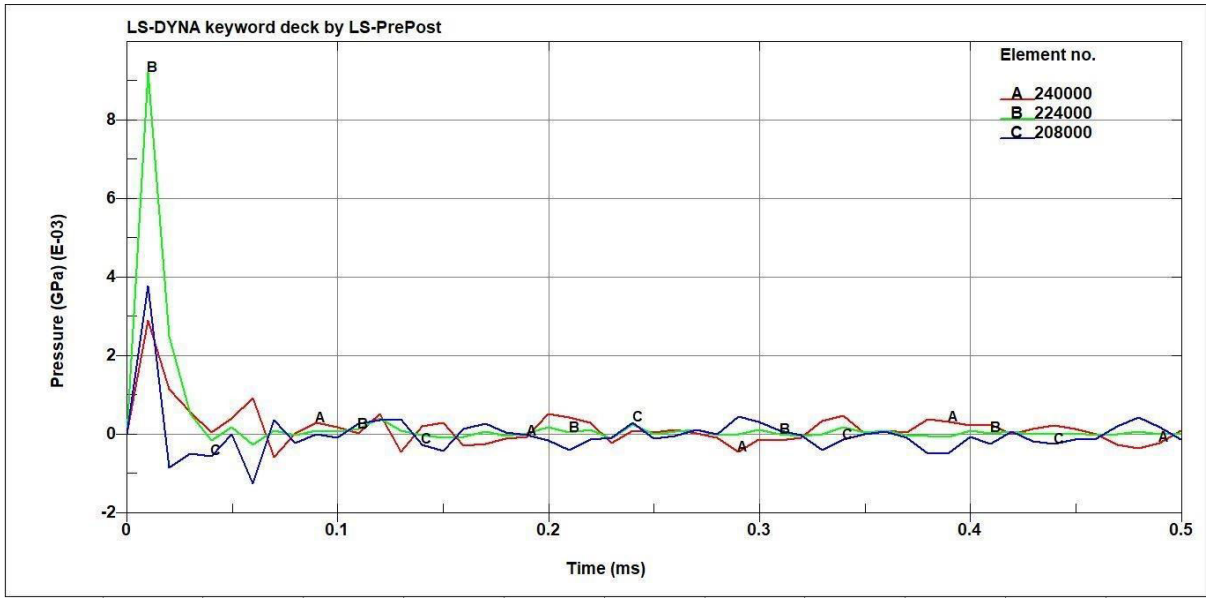

Figure6.3Pressurevstimeatdifferentlocation

6.1 STRESSVARIATIONINZ- DIRECTION:

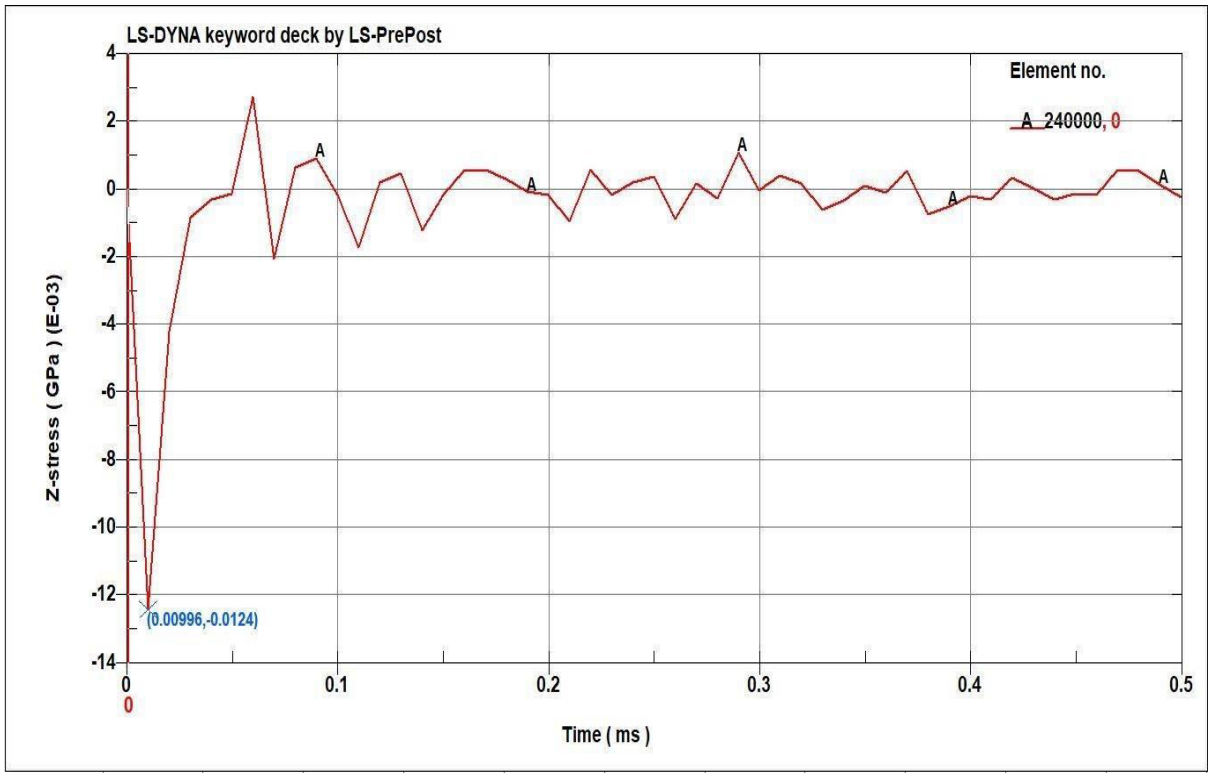

Figure6.4z-stressvstimegraph

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Asthedetonationoftheexplosivecreatesablastwavewhichmoveswithaver yhighvelocity and exerts an axialpressure on the plate and producing a compressivestress in the plate. By applied load there isa reduction inthe length of the materialalong the load of application.The maximum pressure acting on the structure is 2.9MPaatthearrivaltimeof0.00996millisecond,hencethemaximumc ompressivestress of 0.0124 MPa also act at the same time. Figure 6.4 shows the stress variationintheplateatdifferenttimeinterval.

Stressvariationatdifferenttimeinterval

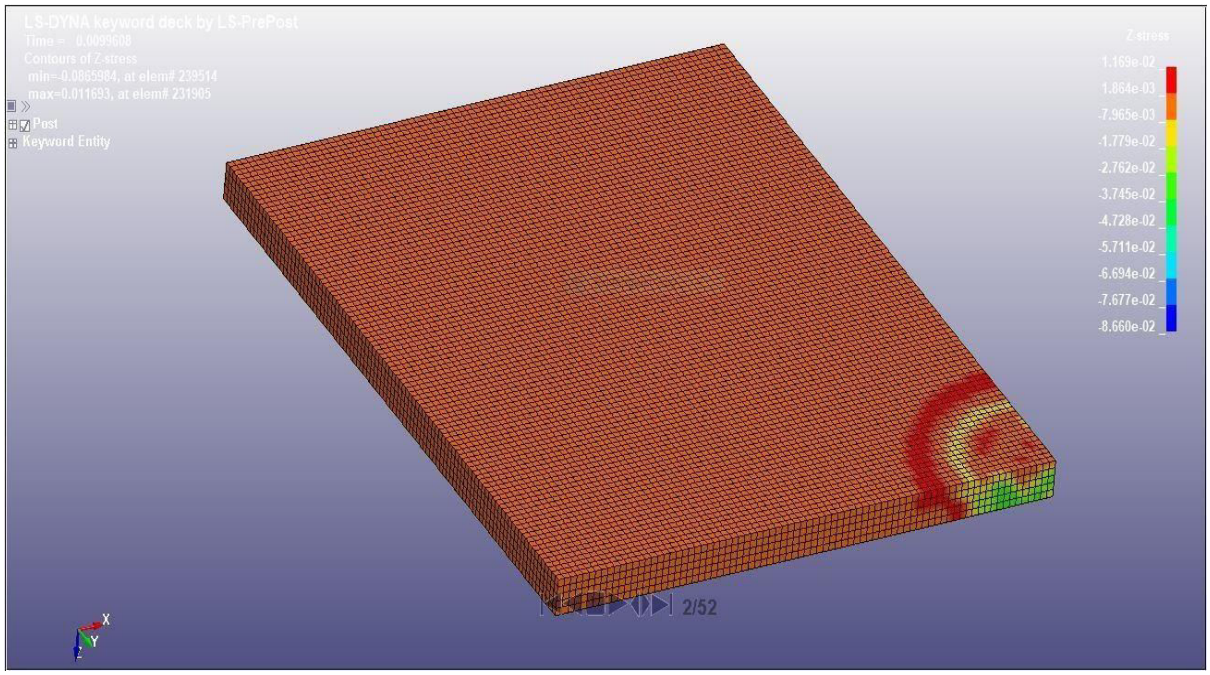

Figure6.5(a)Stressvariationat0.01millisecond

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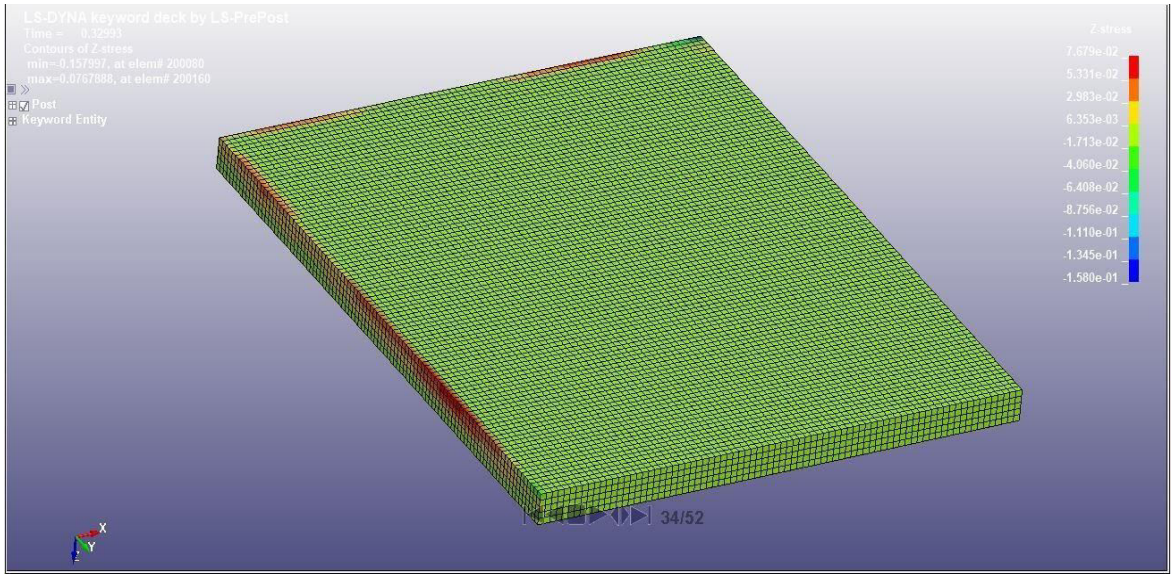

Figure6.5(b)Stressvariationat0.03millisecond

6.2 DISPLACEMENTORDEFORMATIONINTHESTRUCTURE:

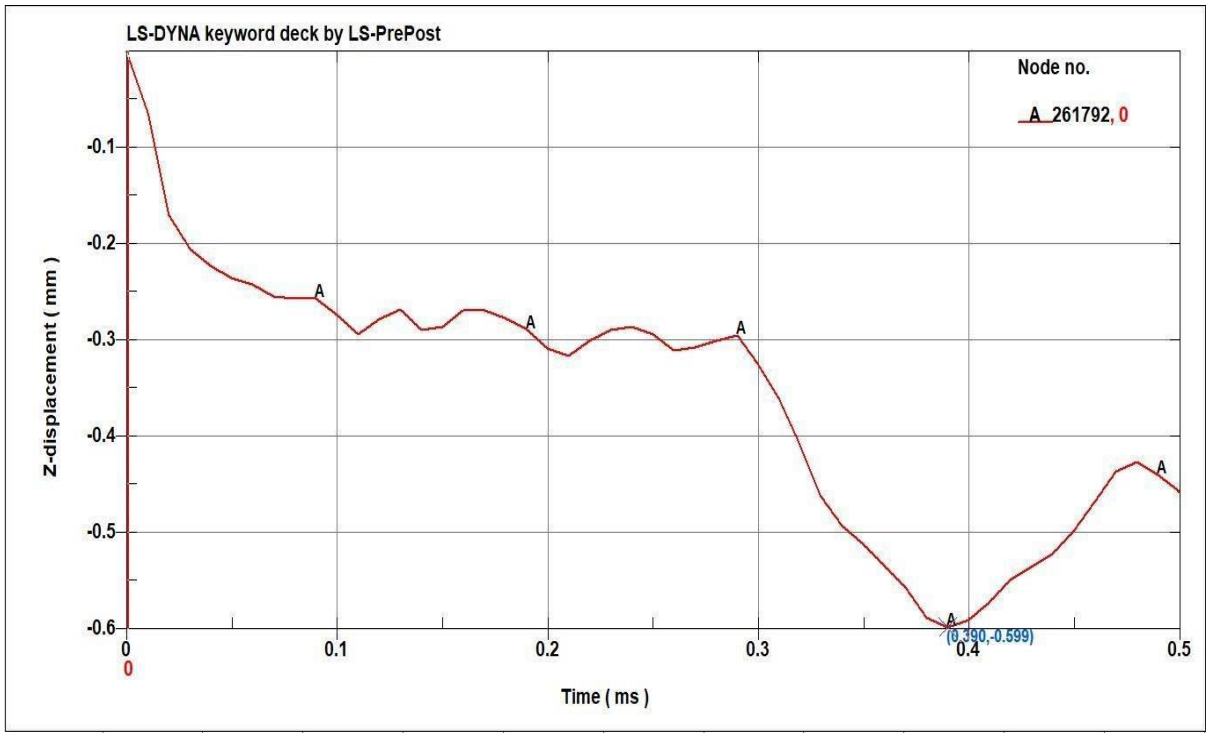

Figure6.6Displacementvstimegraph

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Structuralloadsareansignificantattentioninthedesignofanystructure.Blastwavescau se impairment by a combination of important compression of the air in oppositeof the wave. Distortion mentions to any differences in shape or size of an elementdue load applied. Tensile (pulling) forces, compressive (pushing) forces, shear,bending or torsion (twisting) are the result of the first case. In the another case, themost important aspect, which isdeterminedby the temperature, is the flexibility ofthe structural imperfections such a grain boundries, point vacancies etc. Dependingupon the type of material used, size andgeometryof the structure and the forcesacting on the structure various types of deformation may result such as elasticdeformationorplasticdeformation.

Displacementinstructureavarioustimeinterval

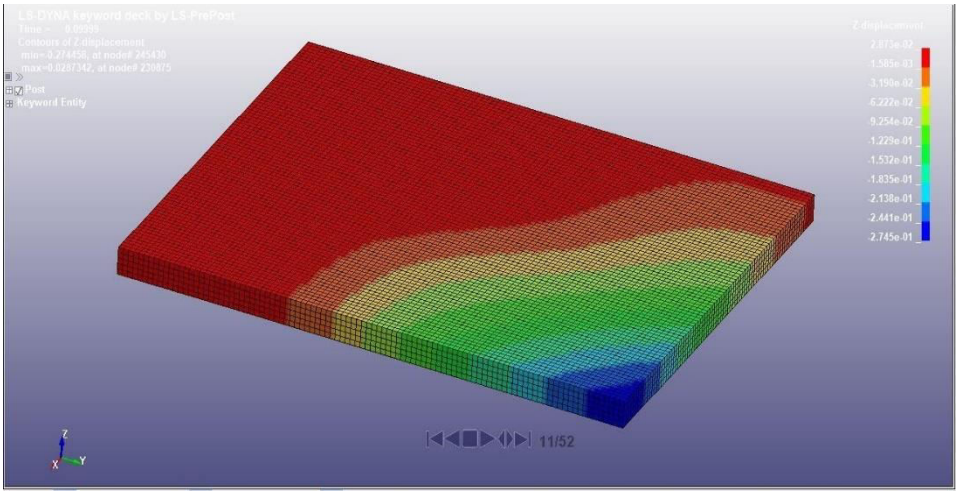

Figure6.7(a)Displacementinstructureat0.1millisecond

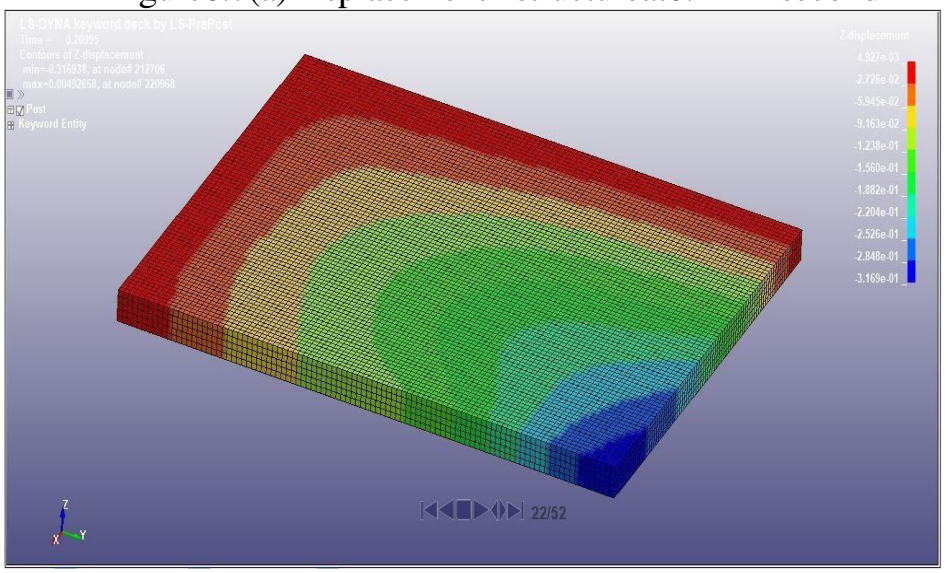

Figure6.7(b)Displacementinstructureat0.2millisecond

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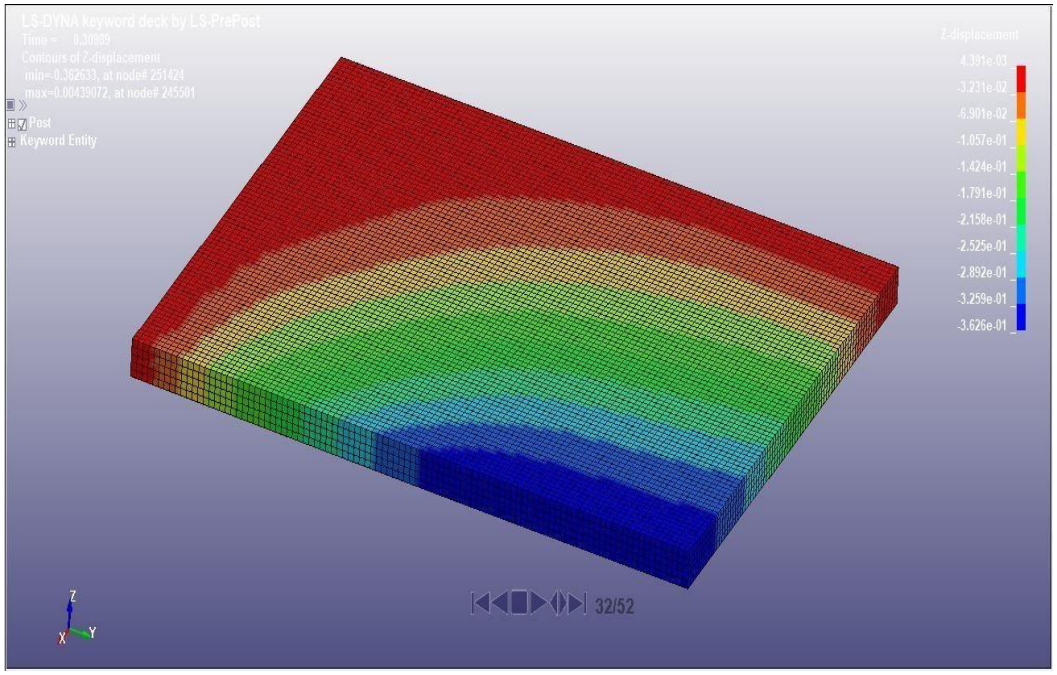

Figure6.7(c)Displacementinstructureat0.3millisecond

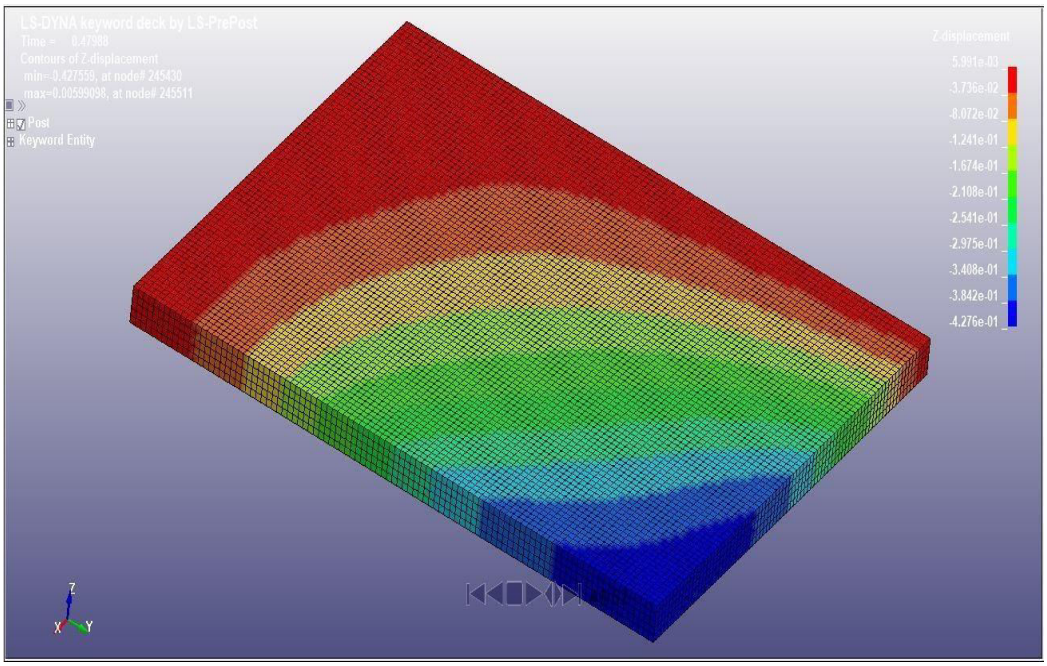

Figure6.7(d)Displacementinstructureat0.4millisecond

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CONCLUSION:

The analysis of blast loading on the rectangular steel plate is investigated using LS-DYNA. This study examines the performance i.e. pressure variation, stress variationin z-directionanddisplacementofsteelplatesubjectedtoblastloadsusingcommercial LS-DYNA software. The blast load was simulated using an ArbitraryLagrangianEulerian (ALE) method, with Fluid Structure Interaction (FSI) betweentheEulerian blast and Lagrangian target models. Analysis of the structures against theabnormal loading condition like blast loadsrequiringdetailed understanding of blastphenomenon.

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