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FE modelling of low velocity impact on RC and prestressed RC slabs

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Abstract. The present study deals with the simulation of low velocity impact on prestressed and reinforced concrete (RC) slabs supported with different end conditions. The prestress is pre-applied on the RC slab in an analytical approach for the prestressed slab. RC slabs with dimensions 500×600×60 mm, 500×600×80 mm and 500×600×120 mm were used by changing support condition in two different ways; (i) Opposite sides simply supported, (ii) Adjacent sides simply supported with opposite corner propped. Deflection response of these specimens were found for the impact due to three different velocities. The effect of grade of concrete on deflection due to the impact of these slabs were also studied. Deflection result of 500×500×50 mm slab was calculated numerically and compared the result with the available experimental result in literature. Finite element analyses were performed using commercially available ANSYS 16.2 software. The effectiveness of prestressing on impact resistant capacity of RC slabs are demonstrated by the way of comparing the deflection of RC slabs under similar impact loadings.

Keywords: finite element; prestressing; low velocity impact; concrete; support conditions; floor slab

1. Introduction

The Reinforced concrete (RC) slabs are integral part of any construction, be it a framed structure or of a load bearing wall system. Concrete slabs designed for the residential building indirectly considered the effect of impact loads by adopting safety factor for the loads etc. However, there is a distinct difference in the response of the concrete slab subjected to dynamic loads when compared to the response of the same subjected to static load. Therefore, this design consideration (impact load) is very important in cases such as structure subjected to vehicle impact, marine structures subjected to ice impact and structure subjected to sudden explosions. Impact load is nothing but a load applied on a structure with very short duration. When a concrete slab is subjected to impact load, then that impact energy of the impactor is a main cause for the deformation of concrete.

Many researches have been done on the behavior of reinforced concrete elements subjected to impact for quite some time now. Mostly researchers have studied the effect of fiber reinforced concrete slab subjected to impact load or some research were focused on effect of special additives added to the conventional concrete slab subjected to impact. Suaris and Shah (1982) studied the effect of fiber reinforced concrete subjected to high strain rate loading in order to derive the basic mechanical properties for the use in more rational design of fiber reinforced concrete structures by the way of reviewing the equations proposed by the various researchers for the impact resistance of fiber reinforced concrete. Ong *et al*. (1999) studied the effect of addition of 3 different fibres such as polyolefin, polyvinyl alcohol, and steel fibers in various proportions in concrete square slab of 1000 mm size and 50 mm thickness subjected to low velocity impact. They concluded that the hook ended steel fibers have performed much better in cracking and energy absorption characteristics when compared to other fibers. Ramakrishna and Sundararajan (2005) investigated the impact resistance of cement mortar slab reinforced with 4 different natural fibers in different proportions. They determined that coir fiber has maximally increased the impact resistance of the slab by 18% compared to plain cement mortar slab. Rao *et al*. (2010), Elavarasi and Mohan (2018) investigated the SIFCON two-way slab subjected to impact loading. Their research revealed that SIFCON slab with 12% fiber volume fraction exhibits excellent performance in strength and energy absorption characteristics. Farnam *et al*. (2010) performed the impact test on High-performance fiber-reinforced cement based composite (HPFRC) panels up to an impact at which failure occurs. They also have performed parametric studies by numerical simulations using LS-DYNA. Almusallam *et al*. (2013 and 2015) performed experimental studies on the effectiveness of hybrid fibers in enhancing the impact resistance of slab. Their test results proved that the hybrid-fibers in the concrete subjected to projectile impact has left smaller crater volumes and reduce the spalling and scabbing damage compared to the normal concrete slab. The hybrid-fibers arrest the crack development and thus minimize the size of the damaged area. Dey *et al*. (2014) investigated the impact response of fiber reinforced aerated concrete and plain autoclaved aerated concrete. Their results indicated that use of 0.5% volume fraction of polypropylene fibers

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resulted in more than three times higher flexural toughness when compared to the flexural toughness of plain autoclaved concrete when subjected to impact load. Similarly, host of researchers have studied the impact response of different types of fiber reinforced concrete such as Foti and Paparella (2014) used the fibers obtained from PET bottles as a substitute for reinforcing steel in concrete. Tabatabaei *et al*. (2014) studied the effect of long carbon fiber reinforced concrete subjected to impact, Máca *et al*. (2014) given the mix design of Ultra High-Performance Fiber Reinforced Concrete (UHPFRC) and studied the impact response of such slab. Nicolaides *et al*. (2015), Peng *et al*. (2016), Yu *et al*. (2016), recently Yoo and Banthia (2017), Li *et al*. (2018), Ranade *et al*. (2017), Luccioni *et al*. (2017), Mao and Barnett (2017), Rajai *et al*. (2017), Prem *et al*. (2017) and Ngo *et al*. (2018) also have worked on the similar line in UHPFRC. Amar Prakash *et al*. (2015) numerically investigated the steel fiber reinforced cementitious composite (SFRCC) panels subjected to high velocity impact. Mastali *et al*. (2015) studied the effect of functionally graded reinforced concrete having no reinforcement subjected to projectile impact. Mastali *et al*. (2016) studied the effect of self compacting concrete made with recycled glass fiber reinforced polymers subjected to impact. Pham and Hao (2016) presented the detailed review of concrete structures strengthened with fiber reinforced plastics under impact loading. Eftekhari and Mohammadi (2016) studied the impact behavior of carbon nanotube reinforced concrete. Wang and Chouw (2017) studied the impact resistance of coconut fiber reinforced concrete subjected to impact. Mohammad *et al*. (2017) studied the effect of addition of waste polypropylene carpet fibres in conjunction with palm oil fuel ash (POFA) as supplementary cementing material replacing ordinary Portland cement by 20%. The positive interaction between carpet fibres and POFA leads to high tensile strength, flexural strengths and impact resistance, thereby increasing the concrete ductility with higher energy absorption and improved crack distribution. It is concluded that waste carpet fibres and palm oil fuel ash can be used as building materials in the construction of sustainable concrete. Ali *et al*. (2017) studied the impact behavior of hybrid fiber reinforced engineered cementitious composite made with short randomly dispersed shape memory alloy and polyvinyl alcohol fibers.

Researchers have also studied the impact resistance of reinforced concrete to find its suitability in different structural applications. Teng *et al*. (2004 and 2005) performed finite element simulation of ogival nose projectile impact on reinforced concrete slab by considering concrete as homogeneous material. Abdel-Kader and Fouda (2014) performed the projectile impact test on concrete slab made with reinforcement arranged in different alignment. Anil *et al*. (2015) studied the effect of different end conditions on the behavior of slabs subjected to impact loads by the way of conducting drop weight hammer test. Effects of the parameters on the damage distribution, number of drops, acceleration-time, velocity-time and displacement-time responses were investigated.

Rajput and Iqbal (2017), and Kumar *et al*. (2018) performed the experimental investigation of ballistic performance of plain, reinforced and prestressed concrete against long rod steel projectiles. The reinforcement in the concrete has been found to be effective in minimizing the scabbing and spalling of material. The initial prestressing in the concrete, stimulated the globalization effect in the deformation process and thus improved the ballistic performance. The ballistic limit of reinforced concrete target was higher than plain concrete target. On the other hand, the ballistic limit of prestressed concrete targets was found to be even more higher than reinforced concrete. Hind *et al*. (2017) performed non linear finite element analysis of flexural response of engineered cementitious composite (ECC) beams to study the effect of aggregate content, slag amount, aggregate size etc. on flexural stress, deflection and strain of ECC beams. Similarly, Kanga and Kim (2017) studied the vehicle impact on steel column-footing connections/junction.

The study on the impact resistant capacity of prestressed RC elements is very limited. However, in the literature there were very few studies found to see the effect of thickness of slab subjected to impact loads along with different boundary condition but the effect of grade of concrete is scarcely available to the best of our knowledge.

In the present study, RC slabs with dimensions 500×600×60 mm, 500×600×80 mm and 500×600×120 mm were modelled by changing support condition in two ways; (i) Opposite sides simply supported (ii) adjacent sides simply supported with the opposite corner propped. Response of these specimens were figured out in the form of deflections due to low velocity impact of three different magnitudes of velocities. Deflection result of 500×500×50 mm slab was calculated numerically through FEM and compared the result with available experimental value in literature. Finite element analyses of the specimens were handled using ANSYS Explicit Dynamics 16.2 software. The effectiveness of prestressing on impact resistant capacity of RC slabs are demonstrated through comparing the results with the bench marking RC slabs under similar impact loadings. Comparisons of response of some prestressed and RC slab with different support type and by varying some important parameters such as grade of concrete, thickness of slab were carried out.

2. Specimen and Configurations

In the present study, finite element simulations of prestressed concrete slab and RC slabs were done using commercially available ANSYS software. Concrete slab of size 500 mm × 600 mm with three different thicknesses such as 50 mm, 80 mm and 120 mm were considered for both prestressed and RC slabs. The slab is reinforced with 8 mm diameter bars of 10 numbers in 500 mm direction and 12 numbers in transverse direction as shown in Fig. 1. The reinforcements were placed at the level 40 mm from the top of the slab in case of 50 mm thickness slab. Similarly, reinforcements were placed at 64mm and 96 mm in case of 80 mm and 120 mm thickness of the slab respectively. Three different grade of concrete such as M30, M50 and M60 were considered. The important parameters considered for the parametric study conducted in the present study are

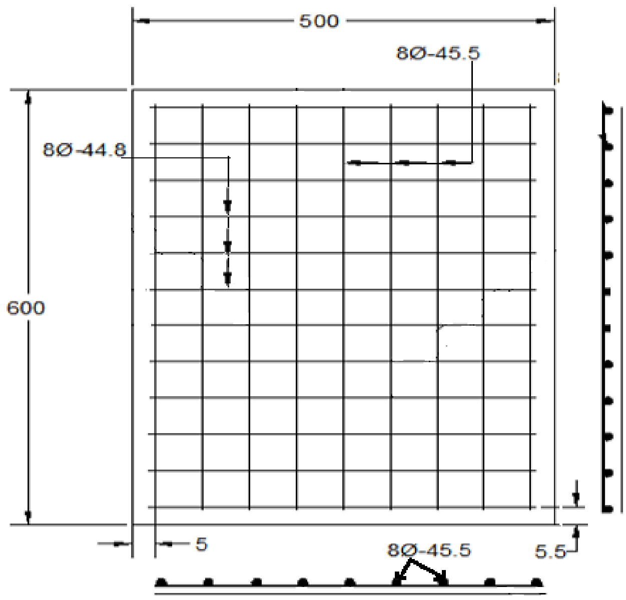


Fig. 1 Specimen configuration

Table 1 Properties of Impactor and Reinforcement

Properties	Impactor and Reinforcement
Density	7850 kg/m^3
Young's modulus	200 GPa
Poisson's ratio	0.300
Bulk modulus	166,670 MPa
Shear modulus	76,923 MPa

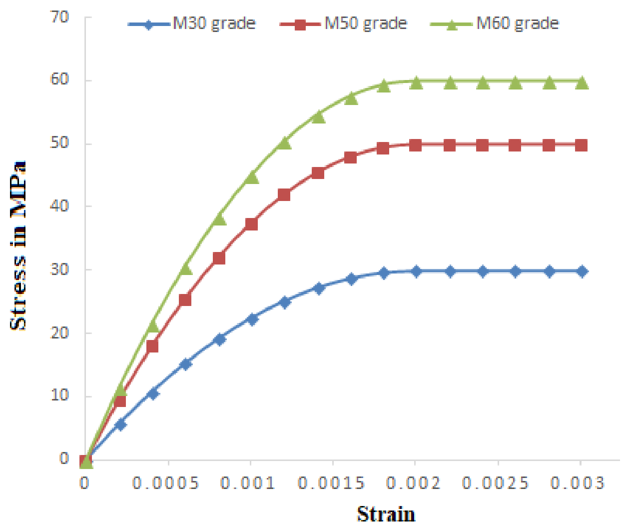


Fig. 2 Stress-strain curve of concrete used in this study from Hognestad *et al*. (1956)

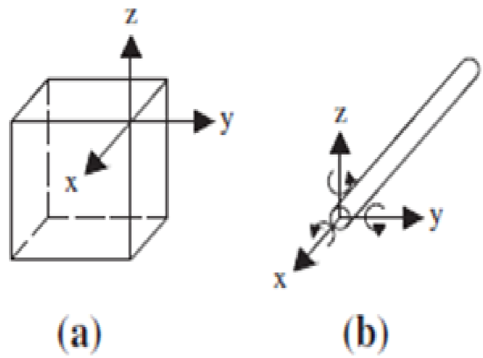


Fig. 3 Elements used for modelling (a) hexahedral, (b) beam (line). Anil *et al*. (2015)

grade of concrete, thickness of slab, impact velocity, support type, and effect of prestressing. Two different types of supports as i) Two opposite sides simply supported, (ii) Two adjacent sides simply supported with the prop at the opposite corner.

3. Finite element modelling of specimen

Non-linear finite element analysis was done both on RC slab and prestressed slab using ANSYS. The concrete was treated using multi linear plasticity model. The material property of concrete was considered using the stress-strain curve model proposed by Hognestad *et al*. (1956). The properties of impactor and steel reinforcement are provided in Table 1 which was used by Anil *et al*. (2015) in their FE modelling of impact on concrete slab. Concrete has been used with three different grades along with reinforcement and steel impactor. The constitutive behavior of concrete has been modelled using multilinear plasticity using the curve shown in Fig. 2.

3.1 Element description

In this study, while generating finite element model of the specimens, hexahedral solid elements were used for the modelling of concrete slabs and reinforcements were modeled using line elements. These are shown in Fig. 3.

3.2 Body interactions and meshing of specimen

Body interactions are used to give surface to surface contact between two different materials in ANSYS explicit dynamics. In present case, "frictional" type body interaction was used between concrete and steel hammer. "Reinforcement" body interaction option was used to give contact between concrete and steel reinforcement. In this study, 20 mm size mesh was selected for all bodies including reinforcement. Explicit property has been selected in preference of meshing. Element mid nodes were dropped in meshing. Meshed model is given in Fig. 4.

The specimens are modeled and analyzed using various analysis systems available in ANSYS with two types of boundary conditions i.e. two opposite sides simply supported and two adjacent sides simply supported together with opposite corner being propped. In analysis systems of ANSYS, static structural was used to model the prestressed slab and explicit dynamics model was used to give impact load on slab in both non-prestressed and also prestressed case. In explicit dynamics, velocity and end time duration are the main input factors needed to apply impact load on slab. The two different support conditions of the slabs shown in Fig. 5.

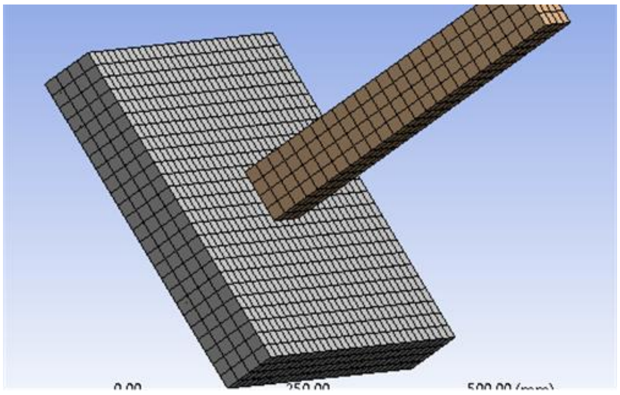
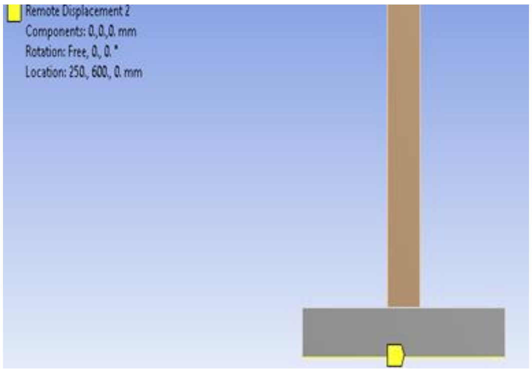
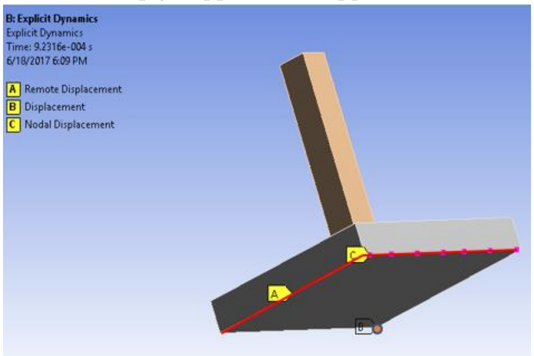


Fig. 4 FE mesh generation



(a) Simply supported on opposite sides



(b) Simply supported on adjacent sides and propped at the opposite corner

Fig. 5 Support conditions

The finite element explicit model was validated with the results published in Anil *et al*. (2015). These researchers had studied the effect of reinforced concrete slab subjected to low velocity impact both experimentally and also in numerical fashion. The current study extended the work to prestressed concrete slab also.

3.3 Loading

The low velocity impact loading was defined at mid portion of the slab. The end time for the loading is taken as 0.92 milliseconds in the present study as per Anil *et al*. (2015). The first velocity considered in the present study is 1154 mm/s, which is adopted from Anil *et al*. (2015), and to ascertain the response of the slab for different impact velocities, additionally, the velocities considered were twice and thrice the first velocity i.e. 2308 mm/s and 3462 mm/s.

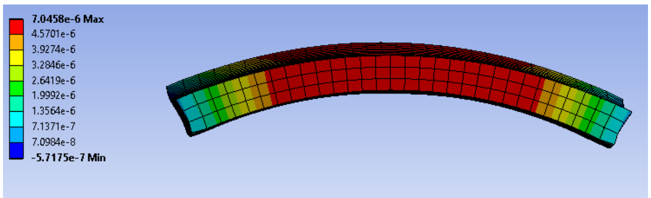


Fig. 6 Hogging deformation of concrete slab

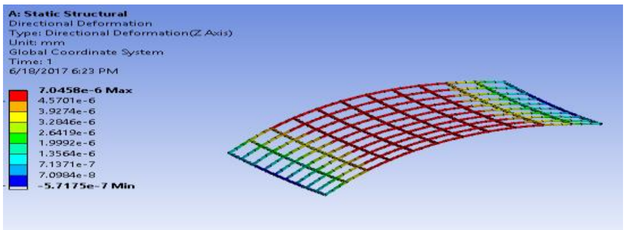


Fig. 7 Hogging deformation of steel reinforcement

3.3.1 Application of prestress to the slab

In case of prestressed slab, prestress was applied to the slab prior to the impact load. Two methods were used in the literature for applying prestressing in numerical modelling. Ngo *et al*. (2007) modeled the prestressing by setting the initial compressive stresses in concrete elements and tensile stresses in steel reinforcement elements. This approach is straightforward in applying the prestress in RC elements. The drawback is that the prestress in concrete elements are not necessarily uniformly distributed along the cross-section and it is not straightforward to determine the prestress distributions. Also, this approach doesn't consider the deformation induced by applying prestress to the reinforced concrete member. When the response mode is governed by shear, under large amplitude short duration impact loading, this initial small hogging deformation may significantly affect the response of the beam. To overcome the above problems, Bi and Hao (2013) developed the relationship between preload applied and the initial hogging deflection of RC beam through analytical method. In their study, the prestress in the beam is modelled by applying initial hogging deformation of reinforced concrete beam. This method is adopted in the present study.

In this paper, application of prestress to the slab was done in two steps, the initial geometry and the initial prestress of the slab was obtained through the implicit analysis i.e. static structural in ANSYS. The bending moment was applied to get the initial hogging deformation. In the second step, the configuration and initial stress state of the beam resulted from the implicit analysis are taken as the initial condition for the subsequent explicit analysis under impact loading in explicit dynamics through its implicit to explicit transfer option.

The applied bending moment is calculated based on the level of prestressing. In this study, the panel is assumed to be prestressed to 10% of its compressive strength. For M30 grade concrete panel of 80 mm thickness, the applied bending moment is calculated as follows:

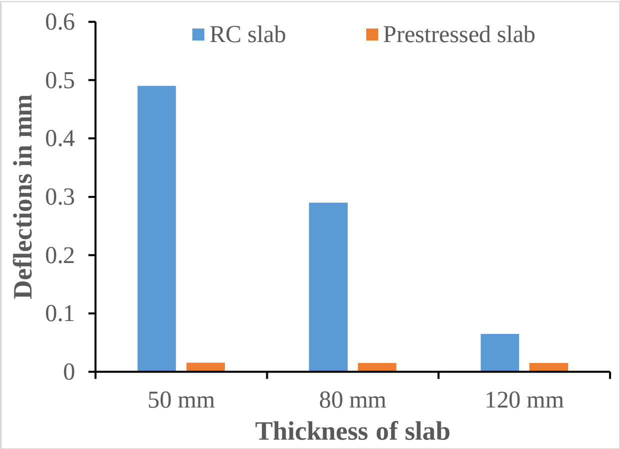
Young's modulus of concrete=$5000\sqrt{f_{ck}}$ = 27,386 MPa

Eccentricity of prestressing force = 20 mm

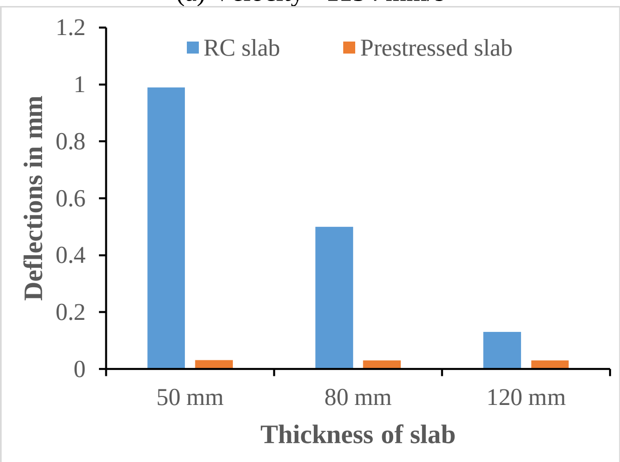
Maximum compressive stress = 3 MPa (10% of 30MPa), this should be equal to sum of the stress due to bending moment and the axial prestressing force.

Table 2 Comparison of deflection of RC slab with finite element result

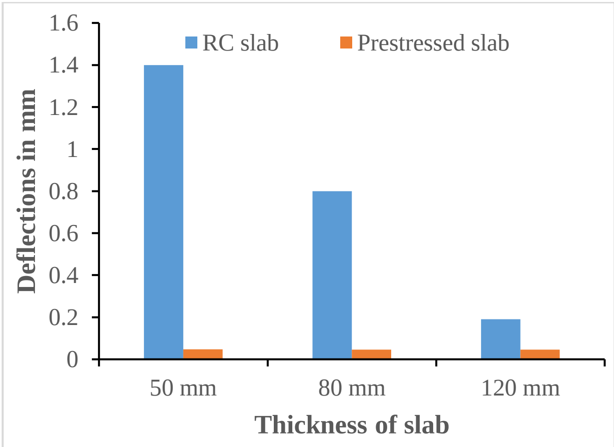
Support condition	Deflection in mm		
	Experimental result. Anil *et al.* (2015)	Finite element result	Error in %
All sides simply supported	0.451	0.421	6.65
All sides fixed	0.363	0.350	3.58



(a) Velocity= 1154 mm/s



(b) Velocity= 2308 mm/s



(c) Velocity= 3462 mm/s

Fig. 8 Effect of slab thickness on deflection of the slab for 1154, 2308, 3412 mm/s velocity for M30 concrete

Therefore, the bending moment applied in this particular panel is 1.536 kNm.

Similarly, for all other panel prestressing has been applied to the slab in this study by using suitable moment. Firstly, prestress has been converted into moment and that moment was given on two opposite sides of the slab. Figs 6 and 7 shows the hogging deformation profile of slab and steel reinforcement respectively.

4. Results of numerical study

4.1 Validation of the model

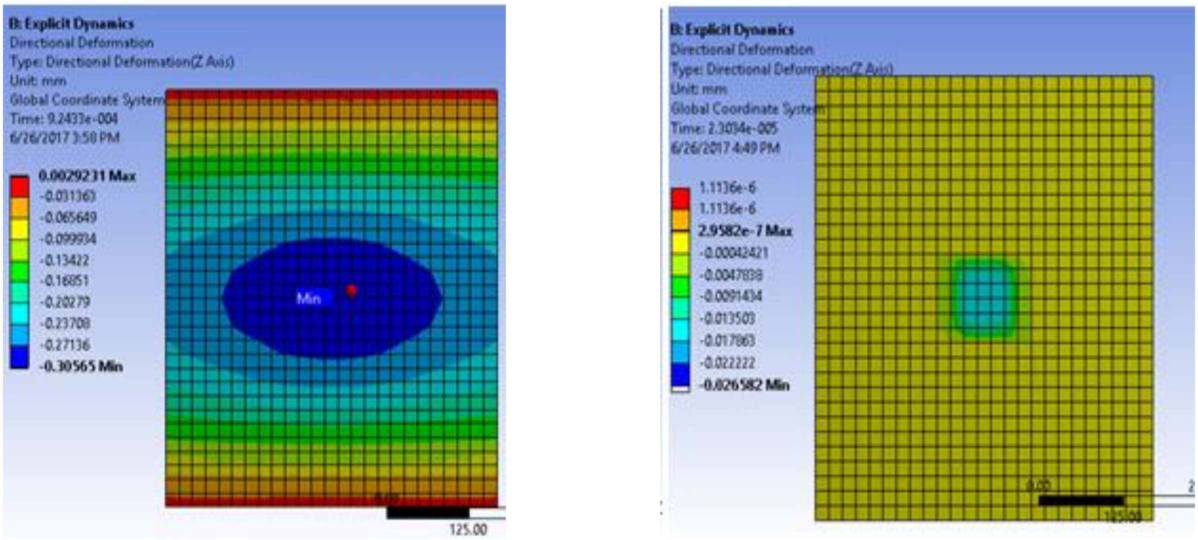
Experimental results available in the literature Anil *et al*. (2015) were used for validating the finite element model developed as described in the previous section. The RC panel of size 500 × 500 × 50 mm with two boundary conditions namely i) all sides simply supported ii) all sides fixed were considered for validating the finite element model. The criteria used for validating the model is deflection of the panel at the centre. Table 2 shows the comparison of deflection of panel measured experimentally with the finite element prediction for these two different boundary conditions of the RC panel. It is observed from the table that the error in prediction of the central deflection is in the range 3-7%. After validations proved to be successful for these two cases, subsequently the models were used to perform analysis considering different parameters as detailed earlier.

4.2 Opposite sides of the slab are simply supported

The deflection of concrete slabs of M30 grade of various thicknesses (50 mm, 80 mm and 120 mm) subjected to impact with three different velocities are shown in Table 3. The results are presented both for RC slab and prestressed slab. It is observed that the ratio of deflections of RC slab to the prestressed slab are in the range of 29-32 for the 50 mm thick slab. Whereas for 80 mm thick slab the ratio of deflections of RC slab to the prestressed slab are in the range of 16.50-19.50. For the 120 mm thick slab, the ratio of deflections of RC slab to the prestressed slab are about 4.2-4.5. It is clear that the prestressing effect on the thin slab is proved to be great when considering thicker slabs. Also, the studies were carried out to see the effect of grade of concrete on the deformation of slab when it is subjected to low velocity impact as shown in Table 4 and 5. The grades of concrete didn’t bear much effect on the 50 mm thickness slab, whereas it had pronounced effect in 120 mm thickness slab wherein the deflection of M60 grade slab is one third the deflection of M30 grade concrete slab. The effect of slab thickness on the deflections of slab for the RC slab and the prestressed slab made of M30 grade concrete is shown in Fig. 8.

It is observed from the Tables 3 to 5 that the deflection values of 50 mm thick slab for all grades of concrete for the impact velocity of 3462 mm/s is same. This may be due to the size of the element.

The deflection contours of 80 mm thickness RC slab and prestressed slab is shown in the Fig. 9.



(a) RC slab (b) Prestressed slab

Fig. 9 Deflection contours of RC slab and prestressed slab for M30 grade concrete for the impact velocity 1154 mm/s

Table 3 Deflection values of slab made of M30 grade concrete (opposite sides simply supported)

Velocity in mm/s	**Deflection in mm**					
	Thickness = 50 mm		**Thickness = 80 mm**		**Thickness = 120 mm**	
	Non-Prestressed slab	**Prestressed slab**	**Non-Prestressed slab**	**Prestressed slab**	**Non-Prestressed slab**	**Prestressed slab**
1154	0.490	0.015752	0.290	0.015169	0.065	0.015103
2308	0.990	0.031501	0.500	0.030169	0.130	0.030000
3462	1.400	0.047100	0.800	0.045409	0.190	0.045305

Table 4 Deflection values of slab made of M50 grade concrete (opposite sides simply supported)

Velocity in mm/s	**Deflection in mm**					
	Thickness = 50 mm		**Thickness = 80 mm**		**Thickness = 120 mm**	
	Non-Prestressed slab	**Prestressed slab**	**Non-Prestressed slab**	**Prestressed slab**	**Non-Prestressed slab**	**Prestressed slab**
1154	0.480	0.014100	0.240	0.013700	0.110	0.013400
2308	0.960	0.028400	0.490	0.027400	0.240	0.027300
3462	1.400	0.042700	0.740	0.041300	0.370	0.040500

Table 5 Deflection values of slab made of M60 grade concrete (opposite sides simply supported)

Velocity in mm/s	**Deflection in mm**					
	Thickness = 50 mm		**Thickness = 80 mm**		**Thickness = 120 mm**	
	Non-Prestressed slab	**Prestressed slab**	**Non-Prestressed slab**	**Prestressed slab**	**Non-Prestressed slab**	**Prestressed slab**
1154	0.470	0.014200	0.210	0.013400	0.170	0.013300
2308	0.960	0.028600	0.430	0.027500	0.340	0.027400
3462	1.400	0.042900	0.650	0.041000	0.500	0.041000

4.3 Two adjacent sides simply supported with opposite corner propped

Finite element simulation of impact on slab (RC and prestressed) which is freely supported on two adjacent edges with its opposite corner propped is also carried out in this study. This case is studied keeping in view the practical situation. The deflection values of concrete slabs of M30 grade of various thicknesses subjected to different velocities are shown in Table 6. This table shows the comparison of deflection values of RC slab and prestressed slab. It is observed that the ratio of deflections of RC slab to the

Table 6 Deflection values of slab made of M30 grade concrete (Adjacent sides freely supported)

Velocity in mm/s	Deflection in mm					
	Thickness = 50 mm		Thickness = 80 mm		Thickness = 120 mm	
	Non-Prestressed slab	Prestressed slab	Non-Prestressed slab	Prestressed slab	Non-Prestressed slab	Prestressed slab
1154	0.520	0.015600	0.300	0.015100	0.150	0.014660
2308	1.000	0.031100	0.600	0.029900	0.310	0.029000
3462	1.570	0.047060	0.910	0.045500	0.400	0.044500

Table 7 Deflection values of slab made of M50 grade concrete (Adjacent sides freely supported)

Velocity in mm/s	Deflection in mm					
	Thickness = 50 mm		Thickness = 80 mm		Thickness = 120 mm	
	Non-Prestressed slab	Prestressed slab	Non-Prestressed slab	Prestressed slab	Non-Prestressed slab	Prestressed slab
1154	0.510	0.014300	0.266	0.013700	0.140	0.013600
2308	1.020	0.028000	0.500	0.026000	0.280	0.025000
3462	1.500	0.041000	0.800	0.041000	0.400	0.040000

Table 8 Deflection values of slab made of M60 grade concrete (Adjacent sides freely supported)

Velocity in mm/s	Deflection in mm					
	Thickness = 50 mm		Thickness = 80 mm		Thickness = 120 mm	
	Non-Prestressed slab	Prestressed slab	Non-Prestressed slab	Prestressed slab	Non-Prestressed slab	Prestressed slab
1154	0.510	0.013900	0.260	0.013300	0.130	0.013300
2308	1.040	0.028600	0.500	0.027000	0.270	0.026000
3462	1.530	0.042000	0.750	0.041300	0.400	0.041000

Table 9 Comparison of deflection values of slabs of different grades of concrete when subjected to impact velocity 3462 mm/s

Grade of concrete	Deflection in mm								
	Thickness = 50 mm			Thickness = 80 mm			Thickness = 120 mm		
	Non-Prestressed slab	Pre-stressed slab	Ratio	Non-Pre-stressed slab	Pre-stressed slab	Ratio	Non-Prestressed slab	Pre-stressed slab	Ratio
M30	1.570	0.04706	33.36	0.910	0.045500	20.00	0.400	0.04440	9.00
M50	1.500	0.04100	36.58	0.800	0.041000	19.51	0.400	0.04000	10.00
M60	1.530	0.04200	36.42	0.750	0.041300	18.16	0.400	0.04100	9.75

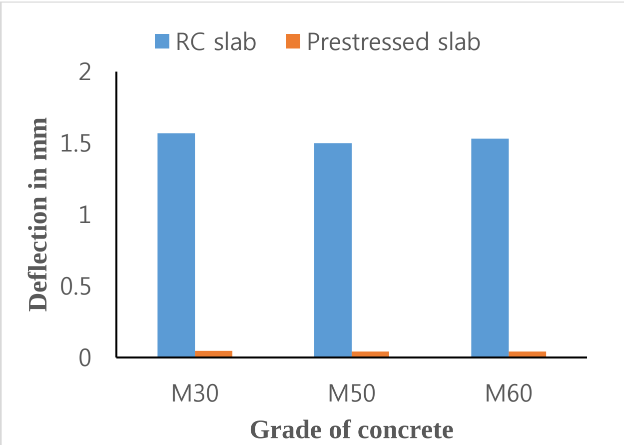
prestressed slab is about 32-33.50 for the 50 mm thick slab. Whereas, for 80 mm thick slab the same ratio varied between 19.75-20.07. similarly, for the 120 mm thick slab, the ratio of deflections of RC slab to the prestressed slab is about 8.9-10.7. It is clear that the prestressing effect on the thin slab is proved to be great when considering thicker slabs. The prestressing effect is nearly three times more effective in 50 mm thick slab than that of 120 mm thick slab. Similarly, the results for the slabs made of M50 and M60 grade concrete are presented in Tables 7 and 8.

The effect of grade of concrete on the deflection of slab is shown in the following Fig. 10 for various thickness of slabs for the impact velocity of 3462 mm/s. These results are also shown in Table. 9.

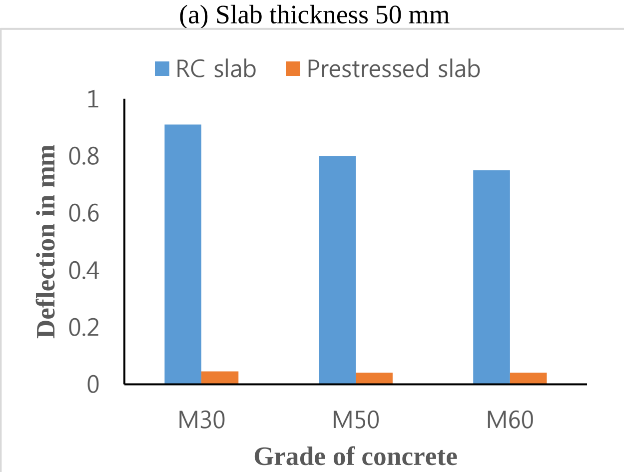
It is observed from this table that, the ratio of deflection of RC slab versus prestressed slab decreases with the increase in thickness of slab for each grade of concrete. But for the same thickness of slab, the grade of concrete did not have much effect on the deflection values. It is almost same for particular grade of concrete.

It is observed from the graph that, as the grade of concrete increases, when the impact velocity is kept constant as the thickness of the slab increases the ratio of deflection of RC slab to that of prestressed slab decreases due to the fact that thicker slab has more resistant to deflection. Also, it is marked that for a constant slab thickness, the difference in the deflection of M50 and M60 grade concrete is very negligible whereas the deflection of M30 grade deviates considerably from other 2 grades considered in this study.

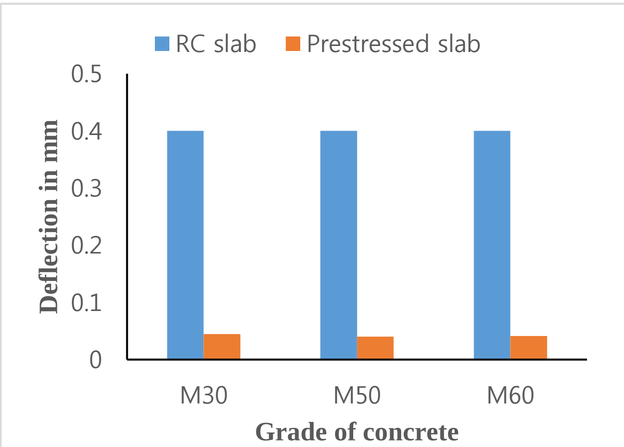
The deflection contour of slab for this particular case is shown in the following Fig 11.



(a) Slab thickness 50 mm

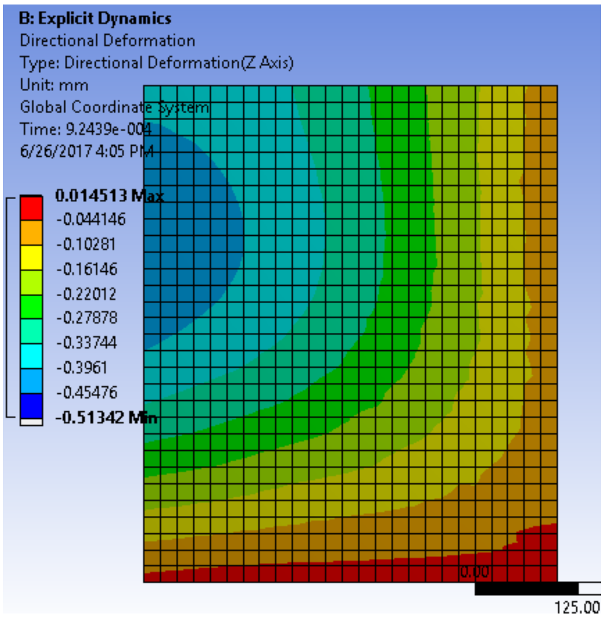


(b) Slab thickness 80 mm

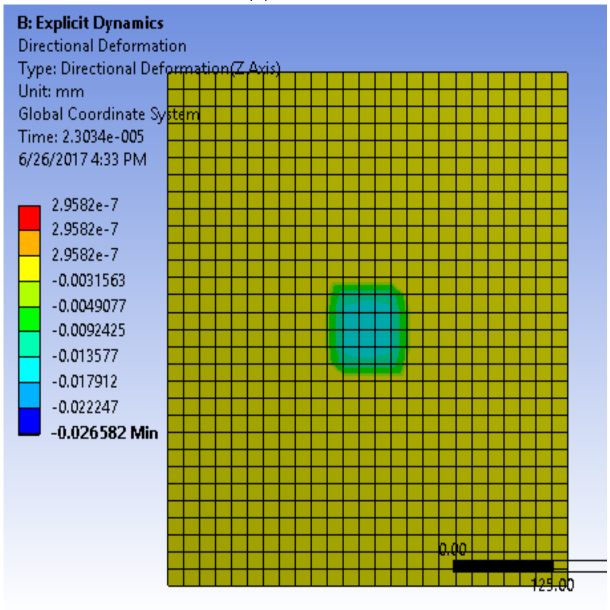


(c) Slab thickness 120 mm

Fig. 10 Effect of grade of concrete on deflection of slab



(a) RC slab



(b) Prestressed case

Fig. 11 Deflection contour of 80 mm thick slab

The stress level in the M30 grade slab which is simply supported on opposite sides subjected to impact velocity 3462 mm/s ranges from 24 MPa for a slab thickness of 50 mm to a value of 34 MPa for the slab of thickness 120 mm in case of RC slab, whereas it varies from 90 MPa for a 50 mm thick prestressed slab to a stress value of 101 MPa for 120 mm thickness. On the contrary, in the slab simply supported on adjacent side, the equivalent stress varied from 76.3 MPa for 50 mm thickness of slab to a value of 188 MPa for the 120 mm thick slab in case of RC slab. In the prestressed case the respective values are 136.5 MPa and 152.5 MPa. Similarly, the stress levels for the slabs with varied parameters were found.

5. Conclusions

Following are the conclusions drawn from the present study, however the results may differ entirely when the slab is subjected to high velocity impact:

- Finite element simulation provides the way to perform parametric study and thus saving the cost involved in preparation of specimens and testing of the same. It also saves plenty of time.
- Cross sectional dimensions of the RC slab affect the

deformation under impact load i.e. the ratio of deformations of RC slab to the prestressed slabs decreased when the thickness of the slab increases. It varies from ~30 for thinnest slab to ~4 for thickest slab of M30 grade. It is realized that prestressing is effective in thinner section than the thicker one.

- For the low velocity impact considered, the effect of grade of concrete on deformation of the slab both in RC slab and prestressed slab is negligible.
- Support conditions affects the deflection of the slab, in general deformation of the slab is more in case of slab whose adjacent sides freely supported with propped opposite corner than the deflection value of slab with opposite sides simply supported.

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