ASPS Conference Proceedings 1: 1159-1164 (2022)

Proceedings of

12th Structural Engineering Convention-An International Event (SEC 2022)

Available at https://asps-journals.com/index.php/acp

High-Rise Structure Parametric study to evaluate Cylindrical Charges on Blast Pressures

Engammagari Ganesh [1], Naveen Tiwari [1], Rohit Naharla [1], P.V. Ramana [2, *]

[1] Research Scholar, National Centre for Disaster Mitigation & Management, MNIT Jaipur, India
[2] Professor, National Centre for Disaster Mitigation & Management, MNIT Jaipur, India

Paper ID - 070537

Abstract

The release of those materials would be contained within the facility'sboundariese so that the impact on the public would be negligible. Hazardous facilities include oil refineries, micro-chip manufacturing,g, etc. Basic Facilities: The buildings not classified as safety-critical or essential/dangerous come under this category. This paper investigates the effect of the cylindrical charge aspect ratio on the spatial distribution of sufficient pressure induced by blast blasting on the face of a concrete element. A clear pattern of the spatial distribution of internal pressure can be seen in the graphical comparison of different aspect ratios. This may be attributed to the complex pressure wave patterns produced by the detonation of cylindrical explosives. Adequate pressure decreases as the aspect ratio of the cylindrical head increases. A 50% reduction in clean printing is observed when the aspect ratio varies between 1 and 2.

Keywords: Blast loading, cylindrical charge, aspect ratio, finite element analysis, adequate blast pressure.

1. Introduction

Large earthquakes are relatively rare. Although it is technically possible to design and construct buildings for these seismic events, it is generally considered uneconomical and unnecessary. The seismic design assumes damage from a significant earthquake, and seismic design concepts based on this have been established over many years. The goal of seismic design is to limit damage to buildings to an acceptable level. A building designed with this goal will experience no damage for small earthquake ground motions, no structural but possibly non-structural damage for moderate earthquake ground motions, and no harm for large earthquakes. It must withstand seismic ground motions without collapsing but with structural and non-structural damage. Investigation of the explosion loading of structures presents a significant challenge due to the complex and transient nature of the system. , the destructive force of this phenomenon and the destructive forces unleashed on networks within the explosion path warrant continued investigation of this phenomenon. Cylindrical explosive charges are standard in military applications and explosives used in commercial quarrying and mining operations. Therefore, analysis of the impact of cylindrical costs in the area of explosive loading in building construction is essential. Limited results are obtained when investigating the spatial distribution of detonation parameters on structural surfaces resulting from the detonation of cylindrical explosives with different aspect ratios. Therefore, the parametric study presented here examines the spatial distribution of blast pressure for concrete components with additional aspect ratio cylinder charges.

The modified Friedlander equation describes the ideal blast wave as shown in Fig. 1 and is given by

$$\text{one p}P_s^+ \ (1 - \frac{t}{T^+} e^{-\frac{bt}{T^+}} \qquad (1)$$

where b is the waveform parameter and is a function of the peak overpressure P_s^+.
p_0 = ambient pressure; t_a = arrival time; P_s^+ = peak side-on overpressure ; T^+ = duration of positive phase ; T^- = duration of the negative phase; P_s^- = peak side-on negative pressure.

Seismic hazards include ground shaking, ground faults, and other effects, each of which can cause building damage and affect the level of performance a building achieves. The damage potential from these impacts is a function of the earthquake's magnitude, the distance of the actual fracture zone from the site, the direction of propagation, the geological composition of the area, and the geological conditions specific to the area—individual sites. The goal of performance-based engineering is to control building damage levels throughout the seismic event that occurs. For ease of practical application, the continuous spectrum of seismic events at a particular site is replaced by a series of discrete seismic events representing the seismic hazard range where the building performance is desired. These discrete seismic events are called seismic design planes.

*Corresponding author. Tel: +919549654189; E-mail address: pvramana.ce@mnit.ac.in

Proceedings of the 12th Structural Engineering Convention (SEC 2022), NCDMM, MNIT Jaipur, India| 19-22 December, 2022

Published online: December 19, 2022
doi:10.38208/acp.v1.635

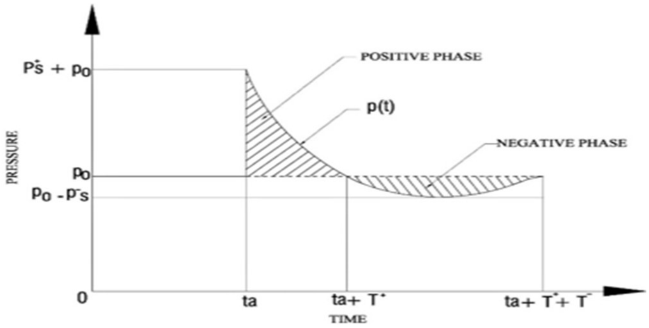

Fig. 1: Ideal blast wave

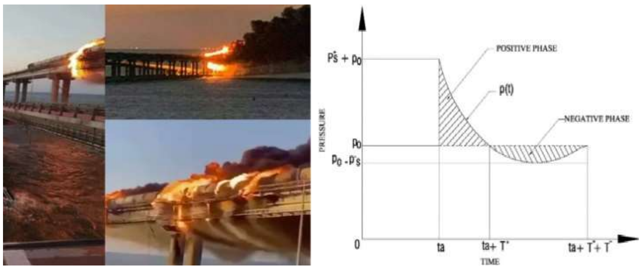

Fig. 2: Bridge blast wave

2. Performance & Explosive charge

A design performance objective of a building can be defined as the desired performance level of the building for each earthquake design level. Design performance objectives are selected based on the building's occupancy, the importance of functions occurring within the building, economic considerations, and the historical or cultural significance of the building. Based on the occupancy, us, es, etc., buildings are grouped into three categories (Vision 2000, 1995). Safety Critical Facilities: The buildings under this category contain large quantities of hazardous materials such as toxic materials, explosives, and radioactive materials, the release of which would result in an unacceptable hazard to the o public. Essential/ Hazardous Facilities: Essential facilities are critical to post-earthquake operations, including hospitals, police stations, fire stations, etc. Hazardous facilities are those which contain large quantities of dangerous mates. Still, the release of those materials would be contained within the facility'sboundariese so that the impact on the public would be negligible. Hazardous facilities include oil refineries, micro-chip manufacturing,g, etc. Basic Facilities: The buildings not classified as safety-critical or essential/dangerous come under this category. The recommended performance objectives of these buildings are summarized in Table 1.

Emulsion explosives (ANFO-based) commonly used in blasting operations are the subject of analysis. The explosive density is 1.2 × 10-6 kg/mm^3, and the minimum detonation velocity is specified as 3.5 × 106 mm/s. The TNT equivalence of the explosive is assumed to be 0.712. Only cylindrical charge detonations are considered in the analysis. The cylindrical head is viewed with the horizontal axis. A layout is shown showing the placement of explosives for square units. The study is based on the explosion of a cylindrical control weighing 0.39 kg. The TNT equivalent weight of the explosive is 0.2777 kg. For the cylinder order,

Table 1: Recommended performance objectives (Vision 2k)

Level	Minimum performance Level		
	Safety Critical Facilities	Essential/Hazardou s Facilities	Basic Facilities
Frequent Occasiona l Rare Very rare	Fully operational Fully operational Fully operational Operationa l	Fully operational Fully operational Operational Life-safe	Fully operational Operationa l Life-safe Near Collapse

Table 2: Details of the explosive charge

Sl. No.	L/D ratio	Charge length (L) in mm	Charge diameter (D) in mm
1	1	74	75
2	1.25	87	69
3	1.5	99	65
4	1.75	108	62
5	2	118	59

the charge length (L) ratio to the charge diameter (D) - aspect ratio significantly influences the overpressure distribution and is considered in five cases. The exact details of fees are listed in Table 2.

The scaling method adopted for the explosives is the Hopkinson – Cranz scaling law, commonly referred to as the cube root scaling law. This law explains the characteristic of the blast waves produced by two explosive charges of the same fierce and similar geometry. At the exact scaled distances, both dirty ectiohaveuce similar blast waves. The scald space boe $Z = \frac{R}{M_e^{\frac{1}{3}}}$ (2)

R is the distance from the target to the charge center, and M_e is the equivalent TNT mass. The center of the explosive charges for all the simulations is kept at the height of 300 mm from the ground. The blasts are simulated for a standoff distance (distance from the target to the charge center) of 1.6 m. The corresponding scaled space is 2.452 m/kg$^{1/3}$ for all the simulations. A nonlinear generic finite element code LS-DYNA performed the numerical simulations. For this research, we used the keyword LOAD_BLAST_ENHANCED. In this work, a pure Lagrangian approach is used. The BLAST=3 option is used to simulate pressure waves induced by LS-DYNA's cylinder charge. BLAST = 3 models an airburst resulting from a moving aspherical warhead. The variable considered is VEL, which is the velocity of the warhead. TEMP the ambient temperature in degrees Fahrenheit. RATIO, the aspect ratio of the aspherical blast front, which is the ratio of the longitudinal radius to the transverse radius (L/D), and VID, the vector ID, represents the longitudinal axis of the warhead. In the simulations performed in this study, the following values of these variables were entered into the analysis. VE = 0 Temperature = 1000F RATIO = L/D value for the specific cylinder charge used. Ground reflection of pressure waves was not considered in this study. In this study, sufficient pressure on the faces of concrete components was evaluated and compared. The correct pressure is the blast load on the structure, whose components are the incident and reflected stresses given by the relationship:

$$P_{eff} = P_r \cos^2\theta + P_i (1+\cos\theta - 2\cos^2\theta) \quad (3)$$

P_{eff} is the appropriate pressure, P_r is the reflected pressure, P_i is the incident pressure, and θ is the angle of incidence. The study adopts the following elements in the finite element analysis. Concrete square unit – Hexahedral constant stress solid elements. Rebars – Hughes -Liu beam elements with cross-section integration. An element size of 12.5 mm is adopted in the study for the finite element analysis. The material model MAT_PLASTIC_KINEMATIC is utilized to model the steel rebars. The primary material properties input during analysis are given in Table 3.

For square structural units, the appropriate contact pressure is obtained from the finite element results with finite element code LS DYNA. Observations are peak values of forces applied to 25 data points in the face of a square structural unit. The 25 data positions are symmetrically arranged around PS 1 on the front. The spatial separation of each data point is in ten-element intervals (12.5 mm) horizontally and 12-element intervals (12.5 mm) vertically. These distances are expressed as proportional ratio values, represented by coordinate 1 in the x direction and coordinate 2 in the y direction. In this coordinate system, PS1 is the origin.

3. Analytical Techniques of Performance Evaluation

The evaluation of the seismic performance of any structure requires estimating its dynamic characteristics and predicting its response to the ground motion to which it could be subjected during its service life. The dynamic features, namely the periods and mode shapes, are obtained through an eigenvalue analysis, and the inelastic time history analyses provide the damage states of the building when it is subjected to various levels of ground motion. The static push-over analysis could determine a structure's lateral load-resisting capacity and the maximum level of damage in the form at the ultimate load. A global damage index of 0.4 or less would represent repairable damage in a structure, while a value of more than 0.4 would mean the damage is beyond repair. A value of 1.0 or greater on the global damage index represents total collapse. An interpretation of the Park and Ang global damage index is given in Table 4.

4. Performance of buildings under UHS-2500

Both frames without infill and infilled frame models are considerable damage under this earthquake hazard level. In the case of frastructurethout without infill, the maximum value of inter-storey drift approaches a value of 0.1%. The value of the full-storey level damage is close to 0.5. The global damage index is relative to 1.2. The value of the damage performance level index suggests that the p achieved by the structure under UHS-2500 events can be categorized as collapse. The building frame is assumed to have lost much of its lateral load-resisting capacity, and it is unsafe for post-earthquake occupancy. The introduction of infilled panels positively affects the performance of the building at higher stories. In this case, the inter-storey drift is close to 0.25%. The storey level damage index is relative to 0.8. The global damage index is close to 1.5, and the overall damage in the structure is relatively high. The structure's performance can be categorized as collapse, and the building would not be available for post-earthquake occupancy.

The seismic performance of a ten-storey building in Mumbai under various levels of earthquake hazard is summarized in Table 5. It is observed that the infill panels generally help a frame achieve better seismic performance at a higher storey level.

Table 3: Properties of Steel

Mass Density (ρ) kg/mm^3	Young's Modulus (E) GPa	Poisson's ratio	Yield Stress GPa
7.86×10^{-6}	200	0.27	0.45

Table 4: Interpretation of the Park and Ang global damage index

Degree of Damage	Physical appearance	Damage index limit
Slight	Sporadic occurrence of cracking	< 0.1
Minor	Minor cracks throughout the building, partial crushing of concrete column	< 0.2
Moderate	Extensive large cracks, the spelling of concrete in weaker elements	< 0.5
Severe	Extensive crushing of concrete, disclosure of buckled reinforcements	< 0.9
Collapse	Total or partial failure of buildings	> 1.0

Table 5: Performance of the ten-storey building near Chiplun fault in Mumbai.

Model	Performance level	
	UHS-500	UHS-2500
Bare frame	Operational	Collapse
Infilled frame	Operational	Collapse

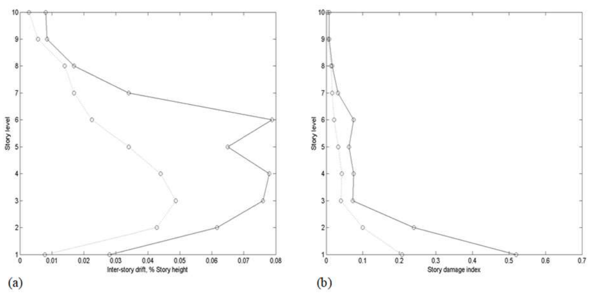

Fig. 3: Ten-storeyed building response to the frame without infill: inter-storeyorey drift (b) storey damage index

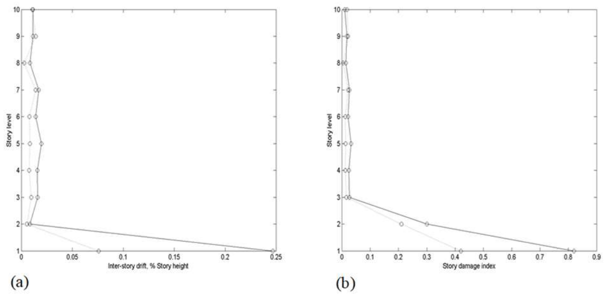

Fig. 4: Ten-storeyed building response to the frame with infill: (a) inter-storey drift (b) storey damage index

Table 6: practical, effective pressure values

The aspect ratio of cylindrical charge	Maxiadequatetive pressure in KPa
1	351
1.25	288
1.5	243
1.75	216
2	180

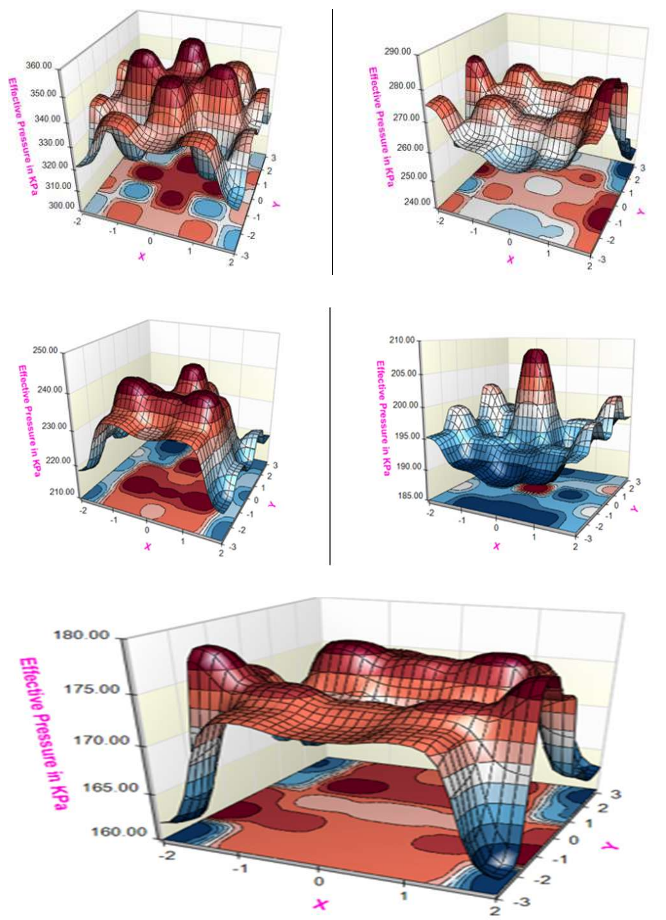

Fig. 5: Effective pressure distribution

From finite element analysis, there are 125 results for square concrete units with cylindrical charge detonation effects at five different aspect ratios. Appropriate pressure is evaluated as a blasting parameter, and its distribution on the surface is examined here. There are 25 observations at sufficient pressure for the given aspect ratio of the cylindrical charge. Observations were presented as 3D surface plots to understand better the spatial distribution and propagation of appropriate pressures on the face of a square concrete unit. 3D surface plots were generated using NCSS software. A 3D surface plot is developed with labeled coordinates representing the spatial separation on the two horizontal axes and the appropriate pressure on the vertical axis. A distinct pattern is observed in the spatial distribution of the proper pressure across the face of a square concrete unit. The distribution pattern is aspect ratio specific, with multiple peaks observed except for the aspect ratio of 1.75. This study shows apparent differences in pressure wave effects caused by different aspect ratios of cylindrical charges. Cylindrical charges generate complex wave patterns, and this spatial distribution can be attributed to this phenomenon. The maximum adequate pressure on the face of the square unit for five different cases is also compared.

Head pressure values are reasonable with an increasing aspect ratio of the cylindrical charge. This corresponds to an extension of the actual Indian administration. The longer the cylindrical direction, the lower the adequate pressure for the same charge weight and scaled distance. Increasing the aspect ratio from 1 to 2 reduces the practical pressure value by 50%.

5. Conclusions

A nonlinear static analysis is performed to determine the lateral load-bearing capacity of the building. Non-structural elements have a significant impact on frame capacity and performance. It has also been observed that the lateral load capacity of the frame improves structural performance. One can calculate the dynamic response of the building using a data set compatible with the hazard spectrum near the fault. Buildings near the Chiplung Fault in Mumbai, India, have suffered severe damage due to increased seismic risk, with the worst performance rated as near-collapse or collapse. For UHS-500 events, the building is fully functional or operational, depending on whether the impact of the infill panels is taken into account.

A parametric study is performed to investigate the spatial distribution of the appropriate pressure on the face of a square concrete unit and five different aspect ratios of a cylindrical charge with the same scale distance. A finite element analysis using LS DYNA's limited element code yields 125 observations of practical pressure values. The following conclusions can be drawn from this study: • A three-dimensional surface plot of the spatial distribution of adequate pressure in the face of a square unit clearly distinguishes the effects caused by the detonation of cylindrical charges of different aspect ratios. Several characteristic peaks are observed except the aspect ratio of 1.75. These patterns show the complex waveforms created by the detonation of cylindrical explosives. • Actual pressure values decrease as the cylinder charge aspect ratio increases. We also show that the appropriate pressure for the same scaled distance decreases as the length of the cylindrical charge increases. A good jet pressure drops by 50% when the aspect ratio changes from 1 to 2.

Disclosures

Free Access to this article is sponsored by SARL ALPHA CRISTO INDUSTRIAL.

References

1. Ganesh, E., Ramana, P. V., & Shrimali, M. K. (2022). Solved structural dynamic mathematical models via a novel technique approach. Materials Today: Proceedings.
2. P.V. Ramana (2021), Modified Adomian Decomposition Method for Uni-Directional Fracture Problems, Sadhana, unique addition, 1-9.
3. B K Raghu Prasad, P.V. Ramana (2012)," Modified Adomian decomposition method for fracture of laminated uni-directional composites," Sadhana Vol. 37, Part-1, pp.33-57.
4. Ayush Meena, P.V. Ramana (2021), Mathematical Model for Recycled PolyEthylene Terephthalate Material Mechanical Strengths, Materials Today: Proceedings, 38, Part 5.
5. Arigela Surendranath, P.V. Ramana (2021), Mathematical Approach on Recycled Material Strength Performance Via Statistical Mode, Materials Today: Proceedings, 38, Part 5.
6. Ayush Meena, P.V. Ramana (2021), High-Rise Structural Stalling and Drift Effect Owe to Lateral Loading, Materials Today: Proceedings, 38, Part 5.
7. P.V. Ramana (2021), Statistical concert of solid effect on fiber concrete, Materials Today: Proceedings, 38, Part 5.
8. Ganesh, E., Ramana, P. V., & Shrimali, M. K. (2022). Unsolved structural dynamic mathematical models via Novel technique approach. Materials Today: Proceedings.
9. Ganesh, E., Shrimali, M. K., & Ramana, P. V. (2021). Estimation of Seismic Fragility in Structural Systems. i-Manager's Journal on Structural Engineering, 10(2), 1.
10. Arigela Surendranath, P.V. Ramana (2021), Interpretation of bi-material interface through the mechanical and microstructural possessions Materials Today: Proceedings,17, Part 3.
11. Ganesh, E., Ramana, P. V., & Shrimali, M. K. (2022), “Solved structural dynamic mathematical models via a novel technique approach,” Materials Today: Proceedings, Volume:62P6 / 3133-3138 / 2022
12. B K Raghu Prasad, P.V. Ramana (2012)," Modified Adomian decomposition method for fracture of laminated uni-directional composites,” Sadhana Vol. 37, Part-1, pp.33-57
13. Ayush Meena, P.V. Ramana (2021), “Mathematical Model for Recycled PolyEthylene Terephthalate Material Mechanical Strengths,” Materials Today: Proceedings, 38, Part 5
14. Arigela Surendranath, P.V. Ramana (2021), “Mathematical Approach on Recycled Material Strength Performance Via Statistical Mode,” Materials Today: Proceedings, 38, Part 5
15. Ayush Meena, P.V. Ramana (2021), “High-Rise Structural Stalling and Drift Effect Owe to Lateral Loading,” Materials Today: Proceedings, 38, Part 5
16. P.V. Ramana (2021), “Statistical concert of solid effect on fiber concrete,” Materials Today: Proceedings, 38, Part 5
17. Ganesh, E., Shrimali, M. K., & Ramana, P. V. (2021), “Estimation of Seismic Fragility in Structural Systems,” i-Manager's Journal on Structural Engineering, 10(2), 1
18. Arigela Surendranath, P.V. Ramana (2021), “Interpretation of bi-material interface through the mechanical and microstructural possessions,” Materials Today: Proceedings,17, Part 3
19. Ayush Meena, P.V. Ramana (2021), “Assessment of endurance and microstructural properties effect on polypropylene concrete,” Materials Today: Proceedings, 38, Part 5
20. P.V. Ramana (2020), “Functioning of bi-material interface intended for polypropylene fiber concrete,” Materials Today: Proceedings,14, Part 2
21. Ganesh E, Ramana P.V, Shrimali M.K (2022), "Unsolved structural dynamic mathematical models via Novel technique approach,” Materials Today: Proceedings Volume:62(2) / 684-691 / 2022
22. E. Ganesh, P.V. Ramana, M.K. Shrimali (2022), "Inelastic materials and mathematical variables for obstacle bridge problem evaluation,” Materials Today: Proceedings Volume:75 / 45-53 / 2022
23. Ganesh E, Ramana P.V, Shrimali M.K (2022), "3D Wave Problems Evaluation and Forecasting Through an Innovative Technique,” Materials Today: Proceedings Volume:68(2) / 634-639 / 2022
24. Ramana P.V. (2022), "Temperature effect and microstructural enactment on recycled fiber concrete,” Materials Today: Proceedings Volume:65 / 56-64 / 2022
25. Meena A, Ramana P.V (2022), "Highly nonlinear mathematical regression for polypropylene material strength prognostication,” Materials Today: Proceedings Volume:62(2) / 696-702 / 2022
26. Ayush Meena, P.V. Ramana (2022), "Mathematical model valuation for recycled material mechanical strengths,” Materials Today: Proceedings Volume:60(1) / 753-759 / 2022
27. Ayush Meena, P.V. Ramana (2021), " Mechanical strength over reinforced concrete without infill structure,” Materials Today: Proceedings (Scopus) Volume:46 / 8783-8789 / 2021
28. P.V. Ramana (2021), "GGBS: fly-Ash Evaluation and Mechanical properties within high strength concrete,” Materials Today: Proceedings (Scopus) Volume:56 / 2920-2931 / 2021
29. Ramana P.V (2021), "Assessment of Mechanical Properties and Workability for Polyethylene Terephthalate Fiber Reinforced Concrete,” Materials Today: Proceedings (Scopus) Volume:38p5 / 2960-2970 / 2021
30. P.V. Ramana (2021), "Salvaged malleable concrete and its perfunctory, micro-structural and robustness competencies,” Materials Today: Proceedings (Scopus) Volume:53 / 2970-2981 / 2021
31. Surendranath A, Ramana P.V (2021), "Recycled materials execution through digital image processing,”

Materials Today: Proceedings (Scopus) Volume:46 / 8795-8801 / 2021

32. Kunal Bisht, Ramana P.V (2020), "Gainful utilization of waste glass for the production of sulphuric acid resistance concrete," Construction and Building Materials Volume:235 / 117-124 / 2020

33. Ramana P.V (2018), "Sustainable production of concrete containing discarded beverage glass as fine aggregate," Construction and Building Materials Volume:177 / 116-124 / 2018

34. P.V. Ramana (2018), "Influence of iron content on the structural and magnetic properties of Ni-Zn ferrite nanoparticles synthesized by PEG assisted sol-gel method," Materials & Design Volume:465 / 747-755 / 2018

35. Ramana P.V (2017), "Evaluation of mechanical and durability properties of crumb rubber concrete," Construction and building material Volume:155 / 811-817 / 2017

36. P.V. Ramana (2014), "Modified Adomian Decomposition Method for Van Derpol Equations," International Journal of Non-Linear Mechanics Volume:65 / 121 / 2014

37. Ramana P.V (2013), "A Novel Procedure for Solving Multi-Support Obstacle Problems'', International Journal on Mechanical Engineering and Robotics (IJMER) Volume :1 / 108-119 / 2013

38. P.V. Ramana (2013), "An FSM Analysis for Box Girder Bridges," International Journal of Advanced Electrical and Electronics Engineering (IJAEEE) Volume:2 / 9Decomposition

39. Ramana P.V and Raghu Prasad B.K (2013), "Modified Adomian Decomposition Method for Non-linear Dynamic Problems," International Journal of Nonlinear Mechanics Volume:01 / 101-109 / 2013

40. P.V. Ramana and B K Raghu Prasad (2012), "Modified Adomian Decomposition Method for Uni-Directional Fracture Problems," Academy of Engineering Sciences Volume:37 / 33-57 / 2012

41. Ramana P.V and Raghu Prasad B.K (2011), "Modified Adomian Decomposition Method for Multi-Directional Fracture Problems," International Journal of SEWC Volume:27 / 15-22 / 2011

42. P. V. Ramana and B K Raghu Prasad (2011), "Modified Adomian Decomposition Method for Helmholtz Problems," IJEST Volume:7 / 1-17 / 2011

43. Ramana P.V. and Raghu Prasad B.K (2011), "Modified Adomian Decomposition Method for Elliptical Problems," Applied Mathematics and Computation Volume:109 / 8-29 / 2011

44. Ayush Meena, P.V. Ramana (2022), "Mechanical strength evaluation for morsel rubber material via mathematical models," Materials Today: Proceedings Volume:62(2) / 24-32 / 2022

45. Naveen Tiwari, Ganesh, E., & Ramana, P. V. (2022), "Seismic Characterization of Symmetrical Structure Damage and Ductility Obligation." Materials Today: Proceedings

46. Rohit Naharla, Ganesh, E., & Ramana, P. V. (2022), "Seismic Effects on Reinforced Concrete Multi-Storey Structure NDTHA Assessment," Materials Today: Proceedings

47. Ayush Meena, P.V. Ramana (2021), Assessment of endurance and microstructural properties effect on polypropylene concrete, Materials Today: Proceedings, 38, Part 5.

48. P.V. Ramana (2020), Functioning of bi-material interface intended for polypropylene fiber concrete, Materials Today: Proceedings,14, Part 2.

49. Anamika Agnihotri, P. V. Ramana "Strength and Durability Analysis of GGBS & Recycled Materials," International Conference on Advances in Civil and Structural Engineering (ICACSE-2020), May 28-30, 2020.

50. Ganesh, E., Ramana, P. V., & Shrimali, M. K. (2022). Inelastic materials and mathematical variables for obstacle bridge problem evaluation. Materials Today: Proceedings.