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AN ANALYSIS FOR THE IMPACT OF VEHICLES ON COMPOSITE ROAD DIVIDERS

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ABSTRACT
Purpose: This research seeks to tackle the significant number of deaths and injuries resulting from road accidents in India by assessing the shortcomings of conventional concrete road dividers and investigating composite materials as a safer option.
Design/Methodology/Approach: Crash simulations were conducted using the ANSYS Workbench software to evaluate the effectiveness of composite road dividers constructed from epoxy, glass fibre, and thermocol. This research examined their stress concentration, deformation, and durability compared to conventional solid and hollow concrete segments at different impact velocities.
Findings: Composite road dividers showcased exceptional performance, achieving a stress capacity of 11.184 MPa within their elastic limits. They were better at absorbing impacts, leading to decreased vehicle damage and fewer passenger injuries. Furthermore, these composites displayed improved durability, resistance to corrosion, and lower maintenance needs compared to conventional concrete dividers.
Research Limitation: The results are derived from simulated crash tests and may need additional validation through full-scale experimental testing in various environmental and traffic conditions.
Practical Implication: Composite road dividers are economical, durable, and practical means of enhancing traffic safety and minimising fatalities. Their ability to adapt to various traffic situations and withstand weather suits them ideally for contemporary infrastructure requirements.
Social Implication: Composite road dividers enhance road safety and save lives by decreasing the severity of accidents. Their implementation supports sustainable development objectives, improving public safety and reducing the economic impact of road accidents.
Originality/Value: This study emphasises the promise of composite materials as a groundbreaking approach to enhancing traffic safety.

Keywords: *Composite material. concrete. impact forces. road divider. vehicles*

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INTRODUCTION

Dividers are commonly used to separate different types of traffic. For example, they can separate a through carriageway from a service road for local traffic, light and heavy traffic, traffic from turning traffic, a corridor for BRT, and a corridor for non-motorized transportation, such as cycles and rickshaws. Such separators might be a verge, a curb, a railing, low-height central dividers, etc. Rubberised cones, concrete curbs, and electrically or mechanically actuated shift table divider railings are examples of the former, whereas the latter are more flexible and mobile. The different types of road dividers presently used worldwide are shown in Plate 1.

Problems with road accidents are acknowledged on a global scale. Among the many direct and indirect losses, they majorly contribute to casualties. Countries and international organisations have developed technologies, processes, and regulations to prevent accidents. One of the leading causes of death globally, according to the report, is road accidents. One traffic accident occurs every minute in India, and sixteen people die in these accidents every hour, according to some surveys. According to this study, traditional concrete road dividers have a low impact absorption capacity. According to research, this is the leading cause of catastrophic injuries sustained by car passengers in the event of an accident. The ultimate goal of this research is to find a material that can take a hit from the car without transferring any of that force back into the vehicle, therefore minimising or eliminating passenger injuries (Bedi et al., 2013).

The most common material for rigid barriers is concrete. They cause devastating collisions since they do not move when struck by a car. They leave a little trace because they do not redirect, which is a significant plus. For median installations, this is of utmost importance because the barrier will be placed near the traffic lane (Böhm et al., 2020).

Semi-rigid barriers are typically preferred over rigid ones because they result in less severe collisions. The materials used to make them are usually plastic and steel. In addition to preventing careless vehicles from escaping the debris field, semi-rigid barriers can flex to absorb impact energy (Bonin & Ranzo, 2004).

The most common types of flexible barriers are safety fences and cable barriers. Compared to other barriers, flexible ones are the safest and most effective for protecting vehicles and their occupants. Since flexible barriers may deflect objects up to three meters away, their biggest drawback is the additional room they necessitate when placed behind them. Additionally, the deflection area's slope needs to be sufficiently flat to redirect the vehicle properly (Cheng et al., 2021).

The objective and Scope of the work are to perform a static and dynamic analysis of the composite road divider and check its performance by replacing concrete road dividers with

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composite road dividers, which may reduce vehicle damage and the life of the driver. This study includes the impact of the composite road divider and aggregate of different types and proportions on the material's overall properties.

Concrete road dividers suffer from low tensile strength, cracking, and high costs, reducing their effectiveness in absorbing impact. Composite road dividers, made from reinforced fibres and polymer matrices, provide superior durability, impact resistance, and adaptability, making them a better option for road safety applications.

India has faced over 88 million injuries and 24 million fatalities from road accidents since 2000, with many incidents involving collisions with road dividers.

Concrete road dividers, often unable to reduce impact force, lead to severe damage to both vehicles and dividers. Composite road dividers, designed to absorb impact and relax over time, perform superior to concrete barriers, potentially reducing damage and improving safety. This research aims to test and analyse the performance of composite road dividers in impact tests, compare them with concrete dividers, and propose composites as a more durable and effective alternative. The scope includes static and dynamic analysis, aiming to reduce vehicle damage and fatalities while ensuring a longer lifespan for road dividers. Methodologically, the study will cover the materials used in road dividers, analyse their properties, and conduct impact testing through analytical and FEM methods to compare the effectiveness of both types.

Plate 1: Rigid Barrier

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Plate 2: Semi-Rigid barrier

Plate 3: Flexible Barrier

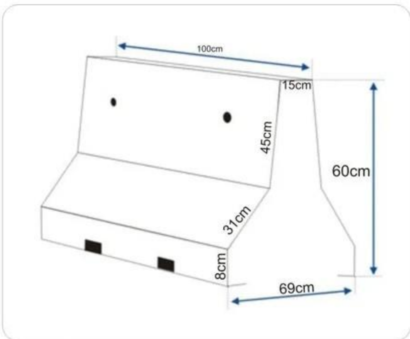

Figure 1: Dimension to prepare Composite Road Divider

LITERATURE REVIEW

Literature review carried out in the area of Composite Road Divider, some of them are as follows:

Impact Test Using Analytical Method

The impact load on concrete barriers focuses on the design of barriers with a height of 813mm, a base of 600mm, and a top width of 240mm. The LSDYNA software was used to construct analytical models, which were then tested using vehicles and laboratory equipment (Mohammed & Zain, 2015).

The impact-load-withstanding strength of geopolymer concrete slabs, finding that specimens with higher molarity of sodium hydroxide solution had better impact energy absorption capabilities (Kiran et al., 2015). Run-off crashes with MRSB are compared using industry-standard tests, aiming to improve the current test standard by analysing new test factors and identifying variables responsible for these issues (Fernández et al., 2019).

The impact forces are assessed in controlled testing, and the values are compared to those predicted by a widely used equation for forecasting rope forces. They found that the widely used method of modelling life-safety ropes as springs is accurate for low test weights and fall factors but becomes less accurate when test weights and fall factors increase (Weber, 2003).

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The introduction of Multi-Walled Carbon Nanotubes (MWCNTs) was investigated in personal computers, revealing that PCs with 1.0 wt % MWCNTs significantly enhanced energy absorption by 36% compared to regular PCs. The microstructural study revealed that the chemical structure of the epoxy matrix was substantially changed by MWCNTs, potentially benefiting several PC structural elements (Daghash et al., 2016).

Secondary collisions in tow-away level crashes after the initial impact with the barrier, finding a 3.5-fold increase in the risk of serious occupant injury compared to a single barrier impact (Gabauer, 2010).

Impact Test Using Experiment Method

The road network remains unchanged, making accommodating changes like increased traffic, longer travel times, unexpected delays, and accidents difficult. A traffic control optimiser is essential for managing traffic on roads, and implementing smarter traffic management systems can help reduce this issue (Retallack & Ostendorf, 2019). In 2018, a self-driving road divider was proposed to shift lanes towards traffic, saving time and fuel money during rush hours. The Smarter Planet app could also improve traffic coordination and reduce human intervention (Dalmia et al., 2019).

Prototype traffic barriers were evaluated in 2003 before full-scale federal testing, using portable barriers filled with water or sand for dead weight. However, few systems have been tested according to federal standards, making public safety more important (Gutkowski & Winkler, 2003). The suitability of unique phenomenological damage models is demonstrated for textile-reinforced composites for complex industrial applications, such as impact-loaded bumper brackets made of 2D biaxially and 2D triaxially braided composites. This allows engineers in the lightweight sector to build textile composites using advanced models, making impact designs and damage evaluations more reliable (Böhm et al., 2020).

Nighttime driving makes road safety more delicate due to the dangers posed by high beams. Plants placed on dividers can serve as natural blind spots, preventing oncoming traffic from blinding one's eyes for just a few seconds (Dhole et al., 2018; Dusane et al., 2016; Shewate et al., 2018) Survey information been used from 500 Chinese drivers to determine how road barriers affect traffic safety, finding that they substantially enhanced traffic safety by decreasing accident rates and improving driver conduct (Cheng et al., 2021).

Impact Test Using FEM Method

The best measurements for concrete barriers are 813 mm in height, 600 mm in base width, and 240 mm in top width. An analytical and experimental model is employed using the LS-DYNA program to examine the concrete barrier plan, which efficiently simulates the impact of vehicles on concrete barriers. Realistic simulations of automobile collisions with concrete barriers are

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made possible by full-scale tests, considering vehicle weights more than 2 t, collision speeds of 100 km/h, and impact angles of 25°. Static testing of bridge concrete barriers is carried out under controlled laboratory environments (Mohammed & Zain, 2015).

Gover Bachelor (2013) studied how well FE and SPH models can capture the dynamics of a composite barrier under impact-loading scenarios. The road safety barrier's behaviour under the H1 test vehicle evaluated the impact conditions using computational nonlinear explicit dynamic calculations. The results showed reduced impact vehicle decelerations and enhanced passenger safety, which can be used to forecast and assess additional road safety barriers, cutting down on the need for costly full-scale collision tests (Vesenjak & Ren, 2003).

(Bonin & Ranzo, 2004) addressed the issue of vehicle-road safety system collisions, using several models to determine how different parameters affect the outcome. (Klasztorny et al., 2019) carried numerical modelling and simulations of the TB11 and TB32 crash tests for specific road safety barriers on a small-radius, horizontal concave arc at a reliable and increased vehicle speed. (C. Wang et al., 2018) investigated the role of several composites in the processes of automobile accidents, including Kevlar-49, high-strength carbon fibre, aluminium metal matrix (KS1275), and aluminium alloy.

(*Patents | Bharati Vidyapeeth*, n.d.) described a road divider with a moulded reinforced polymeric hollow body, which has desirable characteristics such as high impact strength, low weight, ease of handling, durability, and an increase in tensile and flexural strength (Wang et al., 2023; Patil et al., 2022) emphasised the importance of building cars with structures that can absorb impact loads and minimise stress values, protecting the driver and the vehicle's body from harm.

Composite Materials

Several researchers have studied the mechanical properties of polymer concrete, and they have gathered enough data to conclude the impact of factors such as resin type and content, fibre reinforcements, micro fillers, curing conditions, aggregate type and grading, and silane coupling agents on these properties (Bedi et al., 2013).

The best fibre-reinforced composite material was chosen for important uses; this article outlines different types of fibres, how they work, what they are classified as, and how fibre composites are made. As an alternative to individual metals or alloys, fiber-reinforced composites have shown great promise due to their outstanding performance in a wide variety of industries (Rajak et al., 2019).

Advanced composite is a desirable engineering material due to its excellent impact strength, toughness, and high elastic strain energy storage capacity. It is used in various fields like structural elements, aerospace, and automotive design. Road traffic safety management

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systems focus on reducing injuries and deaths from traffic accidents. Composite road dividers outperform concrete in impact strength and elastic strain energy storage capacity and have increased shock absorber capacity (Sanjay et al., 2015).

METHODS

Impact Force Analysis

Mechanical and civil engineers use impact loading analysis for various purposes, such as designing crash barriers, building structures that are resistant to military and terrorist attacks, designing marine structures that are resistant to impact, and designing blonder fences. Determining the impact force at different vehicle speeds is crucial for conducting additional concrete and composite road dividers studies. Therefore, the following equations are used to initially derive the impact forces.

The work done W to bring a body from velocity v to rest or to accelerate it from rest to velocity v is equal to the change in kinetic energy.
Change in Kinetic Energy:

$$\Delta K = \frac{1}{2}mv^2$$

Work Done:

$$W = \frac{1}{2}mv^2$$

Using Newton's Second Law F=ma and the kinematic equation v^2=2as, we can find the acceleration a:

$$a = \frac{v^2}{2s}$$

Substituting this into Newton's Second Law gives:

$$F = m \cdot \frac{v^2}{2s}$$

Work done W is also given by:

$$W = F \cdot s$$

Substituting F=$mv^2/2s$ into the work done formula:

$$W = \left(\frac{mv^2}{2s}\right) \cdot s = \frac{1}{2}mv^2$$

The impact force F, when a body of mass m is accelerated to velocity v over a distance s, is:

$$F = \frac{1}{2}\frac{mv^2}{s}$$

The impact force has been calculated for the Mass as 1200 kg for four cases: 80 km/hr, 60 km/hr,50 km/hr, and 40 km/hr. Also, the displacement allowed for each speed is considered 15 mm, 22 mm, 30mm, and 40 mm.

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The impact forces were first calculated for a speed of 80 km/hr (22.2 m/s), considering displacements of 15 mm, 22 mm, 30 mm, and 40 mm. The results, presented in Table 1, showed that the maximum force occurred at a displacement of 15 mm. Subsequently, the calculations were repeated for a lower speed of 60 km/hr (16.7 m/s) with the same set of displacements. Table 2 indicated that the force was again highest at a displacement of 15 mm. The analysis was then extended to a higher speed of 120 km/hr (33.3 m/s), and Table 3 demonstrated that the maximum force was still observed at a displacement of 15 mm. Finally, for a speed of 100 km/hr (27.8 m/s), the impact forces were calculated for the same displacements, and Table 4 revealed that the most tremendous force continued to be at a displacement of 15 mm.

Table 1: Impact Force Analysis for velocity 22 m/s

Sr No.	Mass(m)	Velocity(v)	Displacement (d)	Kinetic Energy (K.E)	ImpactForce
1	1200 kg	22.2 m/s	15	2.899 J/s	19713.6N
2	1200 kg	22.2 m/s	22	2.899 J/s	13441.09 N
3	1200 kg	22.2 m/s	30	2.899 J/s	9856.8 N
4	1200 kg	22.2 m/s	40	2.899 J/s	7392.6 N

Table 2: Impact Force Analysis for velocity 16.7 m/s

Sr No.	Mass(m)	Velocity(v)	Displacement(d)	Kinetic Energy (K.E)	Impact Force
1	1200 kg	16.7 m/s	15	16.409 J/s	11155.6 N
2	1200 kg	16.7 m/s	22	16.409 J/s	7606.09 N
3	1200 kg	16.7 m/s	30	16.409 J/s	5577.8 N
4	1200 kg	16.7 m/s	40	16.409 J/s	4183.35 N

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Table 3: Impact Force Analysis for velocity 33.3m/s

Sr No.	Mass (m)	Velocity(v)	Displacement(d)	Kinetic Energy (K.E)	Impact Force
1	1200 kg	33.3 m/s	15	6.5424 J/s	44355.6 N
2	1200 kg	33.3 m/s	22	6.5424 J/s	30242.45 N
3	1200 kg	33.3 m/s	30	6.5424 J/s	22177.8 N
4	1200 kg	33.3 m/s	40	26.5424 J/s	16633.35 N

Table 4: Impact Force Analysis for velocity 27.8m/s

Sr No.	Mass (m)	Velocity(v)	Displacement(d)	Kinetic Energy (K.E)	ImpactForce
1	1200 kg	27.8 m/s	15	4.547 J/s	30913N
2	1200 kg	27.8 m/s	22	4.547 J/s	21077.45 N
3	1200 kg	27.8 m/s	30	4.547 J/s	15456.8 N
4	1200 kg	27.8 m/s	40	4.547 J/s	11592.6 N

We tested light and heavy vehicles, making various assumptions about mass, velocity, and crash time. We assumed a constant mass for our analysis and used mass and acceleration to determine the force.

In this context, we analysed a system with the following parameters: a mass of 1200 kg, a velocity of 16.7 m/s, and displacements of 15 mm, 22 mm, 30 mm, and 40 mm. The kinetic energy (KE) was 4.547 J/s, and the corresponding impact forces were 11155.6 N, 7606.09 N, 5577.8 N, and 4183.35 N for the respective displacements.

Experimental Investigation for Composite Road Divided

First, a thermocol mould is created, and then epoxy and glass fibre layers are added up to 10mm. After creating the experimental model, testing was conducted at the Praj Metallurgical Laboratory in Kothrud, Pune. The composite road divider's tensile strength and hardness tests were then conducted. Standard: Tensile strength:ASTM D 638-2014.

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Plate 4: EPOXY Material

Plate 5: Testing Sample

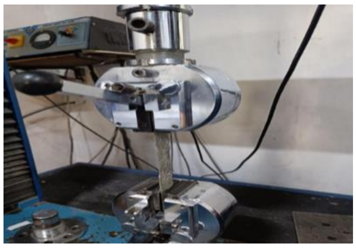

Plate 6: Strength of composite material using Universal Testing Machine

After constructing our composite road divider, we tested it at Praj Laboratory using a universal testing machine (UTM). This versatile device is designed to evaluate the mechanical properties of materials by applying controlled forces and measuring their responses. The UTM features a robust load frame consisting of a base, columns, and a vertically moving crosshead. It measures applied forces using a load cell, which converts mechanical force into electrical signals. The test specimen is secured with appropriate grips or fixtures, and the control system allows precise management of test parameters such as load and displacement. During the test, the UTM applies force or displacement at a set rate, recording data on deformation and applied load in real-time. This data is analysed with specialised software to assess the material's properties, while safety features like emergency stops and overload protection ensure safe operation throughout the testing process.

Table 5: Hardness Tensile Strength

Sr No.	Sample identification	Tensile strength (MPa)	Hardness (Shore D)
1.	Composite Road Divider	29.66	55 to 56

Modelling and Finite Element Analysis of Road Divider

CAD Model of Solid Road Divider

First, it is necessary to establish what tools will be utilised to conduct an accurate impact force analysis on the concrete road divider. We used preexisting materials, such as concrete for the road divider and steel for the vehicle assembly. The 3D model was created using the modelling software Creo.

Launch the software and set up a new document to create a CAD model in Creo. Begin by sketching the car body on an appropriate plane using lines, arcs, and splines, then extrude the

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sketch to form a solid 3D shape. Add details such as doors and windows with additional sketches and modelling tools. Next, sketch and extrude the road divider, creating its 3D form. Assemble the car body and road divider using Creo's Assemblies feature, positioning and aligning the components as needed. Refine the model by adding materials and textures, then save and export the completed model for sharing or further use.

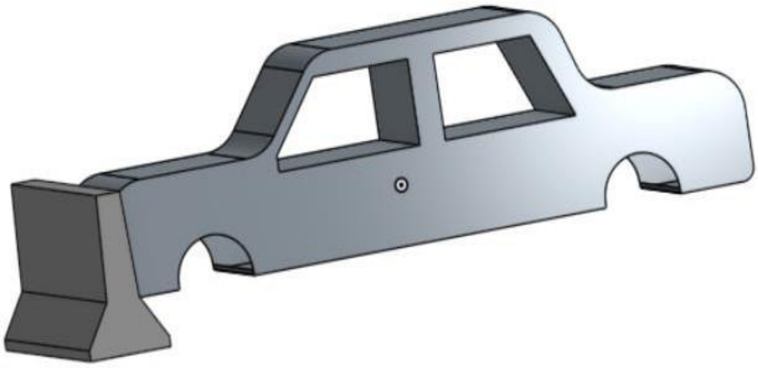

Figure 2: CAD model of solid Road divider with Vehicle

Table 6: Material properties of steel Vehicle Body

Young's Modulus	2×10^5 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.6667×10^5 MPa
Shear Modulus	76923 MPa
Isotropic Secant Coefficient of Thermal Expansion	1.2×10^{-5} /°C
Compressive Yield Strength	250a

CAD Model of Hollow concrete road divider

Here, we will examine the Impact Force Analysis of a Hollow Concrete Road Divider, using preexisting concrete for the road divider and steel for the vehicle's body.

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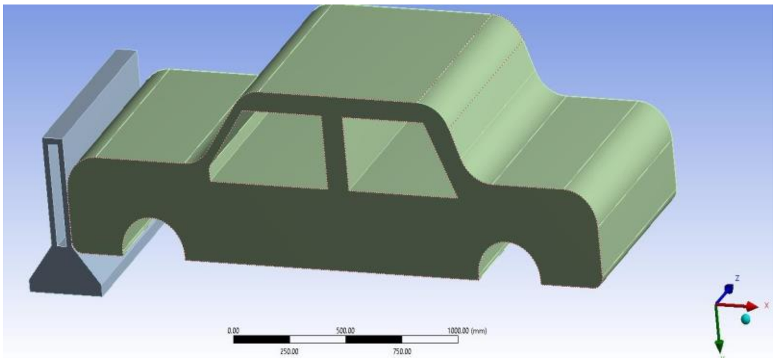

Figure 3: CAD model of Hollow Road divider with Vehicle

Finite Element Analysis of Concrete Road Divider

The FEA (Finite Element Analysis) approach studies impact by determining the maximum stress a car can create upon impact with a road barrier. Road dividers experience stress due to impact loads, and the resulting stress can be calculated using finite element analysis software. The ANSAMS-21 program.

Within Ansys Mechanical Programming, start a static structural analysis using the one in the toolbox. Then, bring the igs file from the CAD model into the Workbench to set the geometry. The geometry environment can also be loaded for stress analysis using explicit dynamic analysis. After bringing the geometry into the ANSYS Workbench, define the materials for the parts by double-clicking on "Engineering Data."

Select the required material from the Ansys material library for the analysis. Here, the road divider is concrete, and the vehicle body is steel. Hence, concrete material and steel materials have been selected and defined for stress analysis.

With the above pre-processing data, the geometry of the road divider and car body is meshed with Solid 186, a hexahedral element with 14879 elements and 38947 nodes.

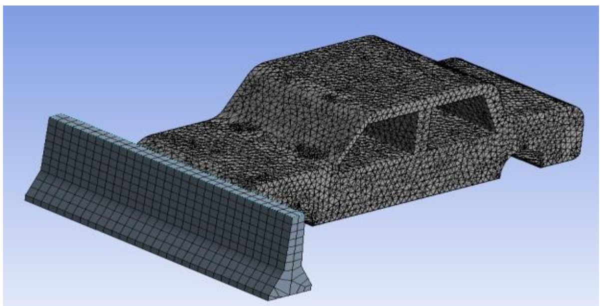

Figure 4: Mesh Model of solid Road divider with Vehicle

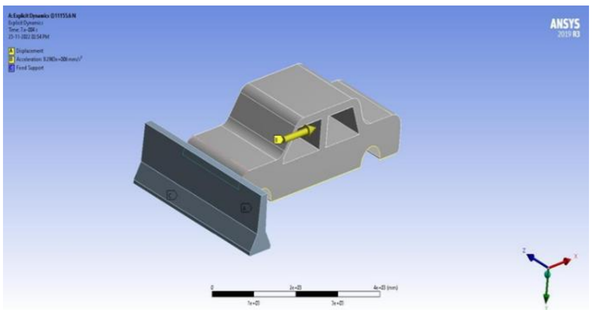

Figure 5: Boundary Condition Applied on solid Road divider with Vehicle

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Boundary Condition Applied on Model:
Created the necessary part-to-part connections in ANSYS Mechanical, obtained the mesh structure, and then defined the necessary boundary conditions, including loads and supports, to obtain the desired system or mechanisms. We can test the road divider's strength by fixing it to the ground in all directions. Then, we accelerate the automobile for collision analysis while allowing for some displacement.

Model Wise Dynamic Analysis Reports
Using ANSYS Mechanical's static structural analysis, you can specify what you want our model to compute or display. In Ansys, we have a static structural analysis that you may observe when selecting a solution option.

Once you are ready, hit the "Solve" button to get the results for our system. Final Findings from the Stress Analysis:
Maximum Equivalent stress concrete- 31.772 MPa
Total Deformation- 2.3745 mm
Shear Stress: 14.248 MPa

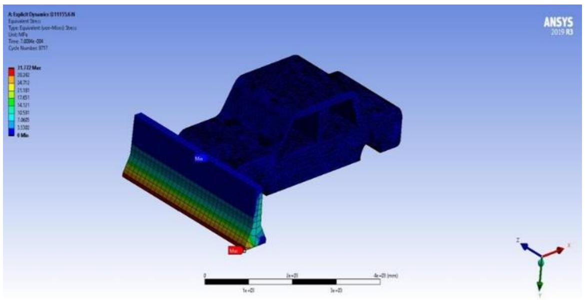

Figure 6: Equivalent Stress on solid Road divider with Vehicle

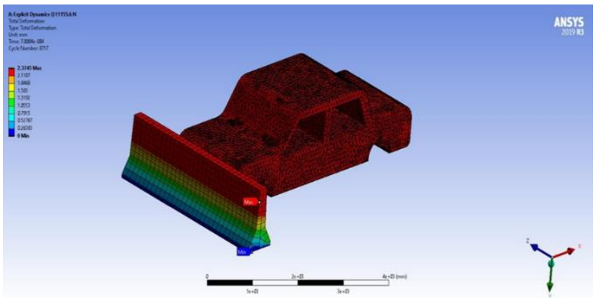

Figure 7: Deformation on solid Road divider with Vehicle

In the above FEA analysis of the concrete road divider, the base is fixed, and a force of 11,155.6 N is applied to one of the wall members. The resulting equivalent stress, maximum principal stress, and total deformation are shown. The equivalent stress, 31.772 MPa, is highest on the wall member, indicated in red. The total deformation is greatest around the apex of the concrete road divider.

After Analysing with the help of ANSYS, we observed that the body's total deformation is 2.3745 mm, as shown in Figure 13.

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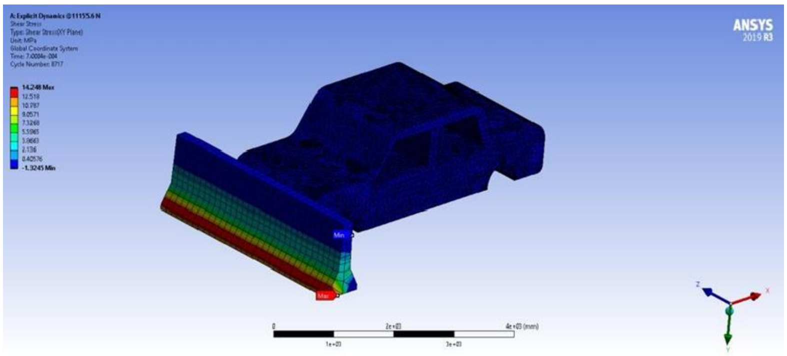

Figure 8: Shear stress on solid Road divider with Vehicle

Hence, we have observed that the Total shear stress developed in the Concrete Road divider after a crash is 14.248 MPa.

Finite Element Analysis of Composite Road Divider

Assessing effects using finite element analysis the finite element analysis (FEA) method is used to determine the highest stress that can be applied to a road divider following a car crash. Road dividers experience stress due to impact loads, and the resulting stress can be calculated using finite element analysis software. The ANSAMS-21 program.

Within Ansys, Mechanical Programming, get a dynamic structural analysis using the one in the toolkit. Then, in order to specify it in the Workbench environment, we require the correct geometry. From the geometry part of the Dynamic Structural Analysis manual, we may import our geometry. We double-clicked "Engineering Data" after importing our geometry into ANSYS Workbench to specify the materials used in our components. We chose one of the materials accessible in ANSYS Workbench's "Engineering Data" section. Another option is to use ANSYS Workbench to build our materials for DSA.

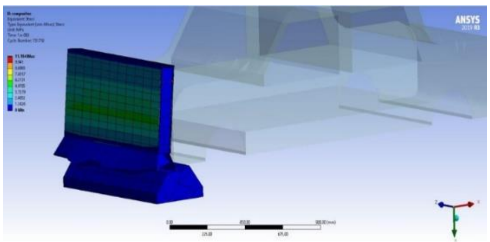

Figure 9: Equivalent Stress on composite Road divider with Vehicle

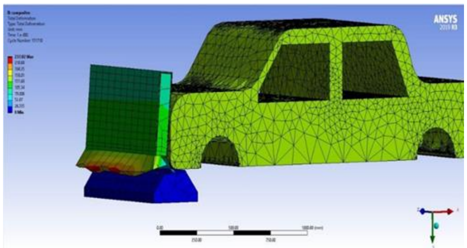

Figure 10: Deformation on composite Road divider with Vehicle

In the above FEA analysis of a composite road divider, the base is kept fixed, and a force of 11155.6 N is applied to one of the wall members. The resultant Equivalent stress, Maximum

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Principal stress, and Total deformation are shown.
As you can see, the equivalent stress, i.e. 11.184MPa

After analyzing the data using ANSYS, we observed that the maximum total deformation on the body is 237.02 mm, as shown in Figure 10.

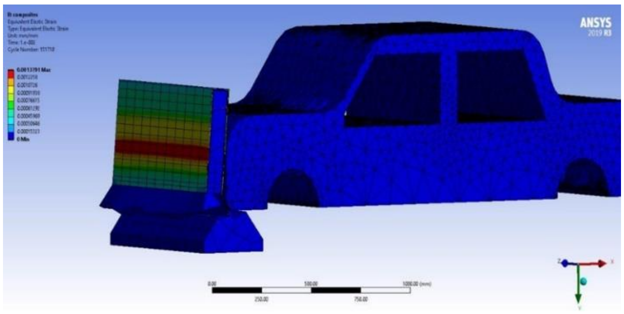

Figure 11: Equivalent Elastic strain on composite Road divider with Vehicle

The results of our analysis using ANSYS suggest that the maximum equivalentElastic Strain on the body is 237.02 mm, as illustrated in fig. 17.

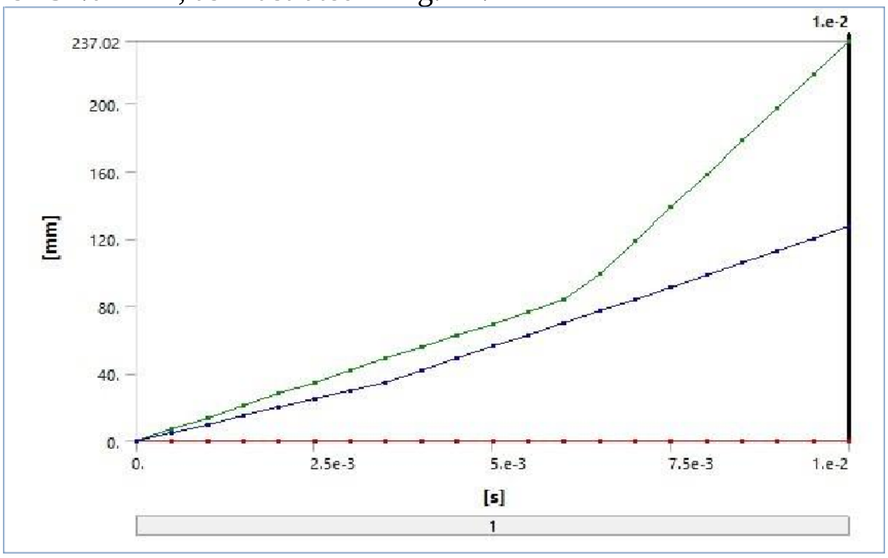

Figure 12: Total Deformation of Composite Road Divider

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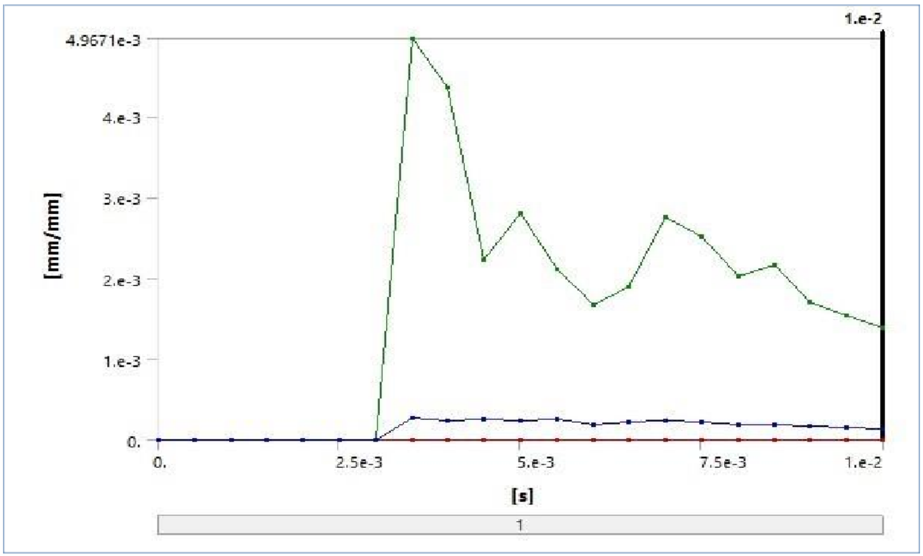

Figure 13: Equivalent Elastic Strain

Table 7: Analysis of Composite Road Divider

Sr.No.	Total Deformation	Equivalent Stress	Equivalent Elastic Strain
1	0	0	0
2	105.34	4.9705	0.00061292
3	237.02	11.184	0.0013791

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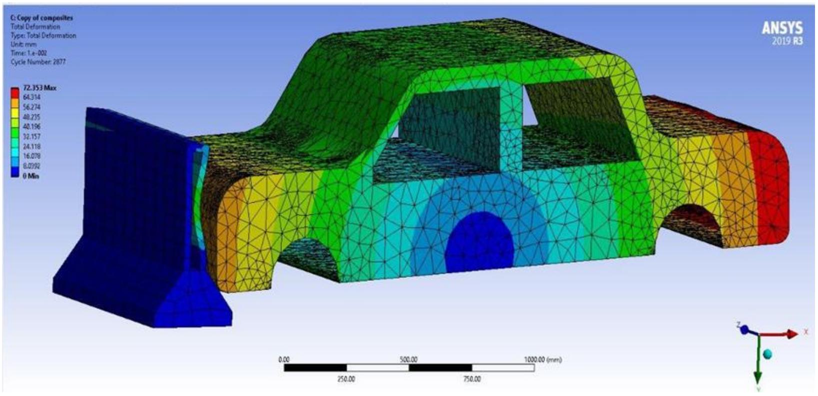

Figure 14: Total deformation on hollow Concrete Road divider with Vehicle

The adopted A N S Y S analysis suggests that the maximum Total deformation on the body is 72.353 mm, as illustrated in Figure 14.

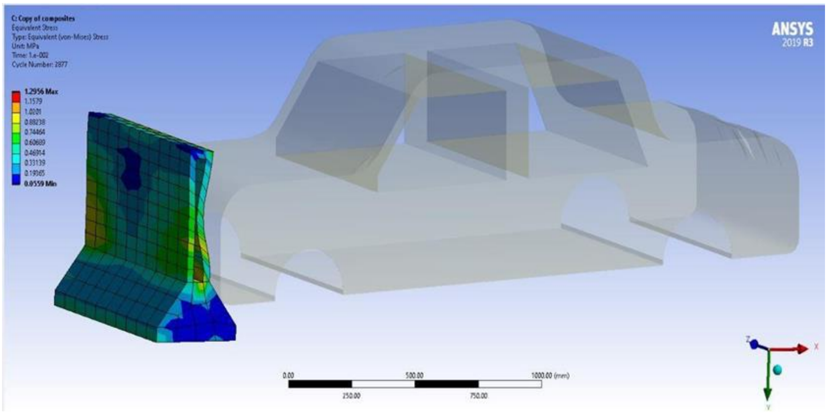

Figure 15: Total Equivalent stress hollow Concrete Road divider with Vehicle

Figure 15 illustrates the results of our analysis using ANSYS, which revealed that the maximum equivalent stress on the body is 1.2956 MPa.

African Journal of Applied Research
Vol. 11, No. 1 (2025), pp.363-387
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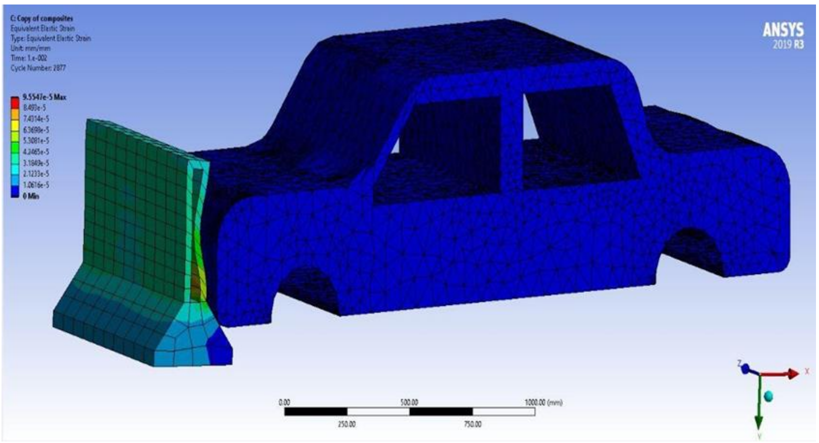

Figure 16: Equivalent Elastic strain hollow Concrete Road divider with Vehicle

Our analysis using ANSYS suggests that the Equivalent Elastic strain onthe body is 9.5547e-5, as illustrated in figure 16.

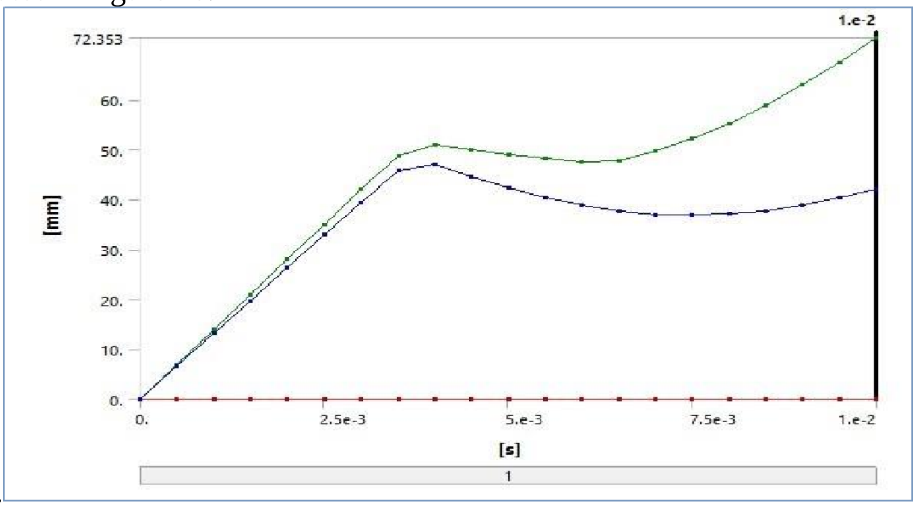

Figure 17: Total Deformation of Hollow Concrete

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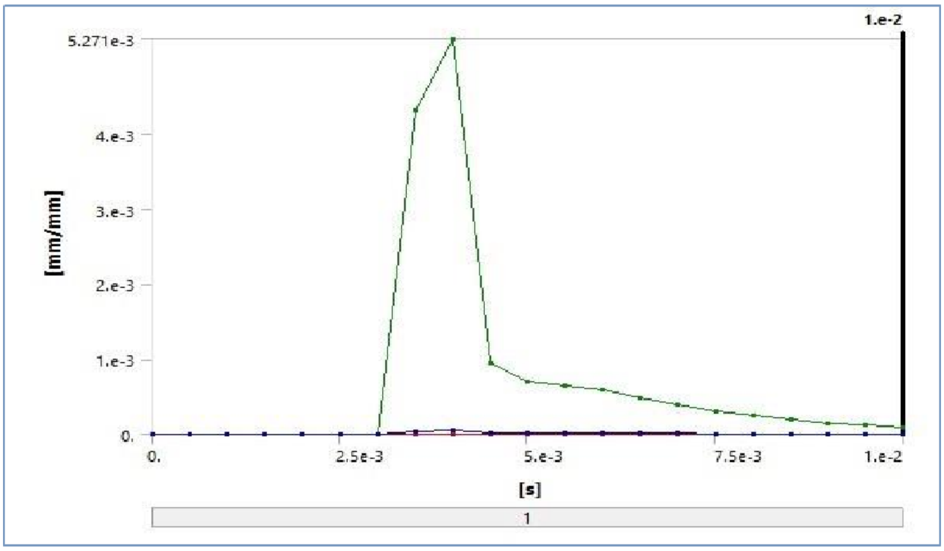

Figure 18: Equivalent Stress of Hollow Concrete

Table 8: Analysis of Hollow Concrete Road Divider

0S0r00000.0 No	Total Deformation	Total Equivalent Stress	Equivalent Elastic Strain
1	0	0.0559	0
2	32.157	0.0689	4.2465e-5
3	72.353	1.2956	9.5547e-5

RESULT AND DISCUSSION

As per the force, analysis carried out for the stress analysis on the solid concrete, hollow concrete, and composite road divider, the impact forces calculated for the displacement of 15 mm, 22 mm, 30 mm, and 40 mm during crash analysis at a speed of 80 km/hr, 60 km/hr, 50 km/hr, and 40 km/hr are shown in Table 9.

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Table 9: Impact Force Analysis for velocity 27.8m/s

Sr No.	Mass (m)	Velocity(v)	Displacement (d)	Kinetic Energy (K.E)	ImpactForce
1	1200 kg	27.8 m/s	15	4.547 J/s	30913 N
2	1200 kg	27.8 m/s	22	4.547 J/s	21077.45 N
3	1200 kg	27.8 m/s	30	4.547 J/s	15456.8 N
4	1200 kg	27.8 m/s	40	4.547 J/s	11592.6 N

An explicit dynamic analysis using the standard analytical tool ANSYS Workbench has been carried out to find the deformation, strain, and stresses over solid, hollow, and composite road dividers. The analysis shows that the stress capacity of composite road dividers is 11.184 MPa, which is under the elastic limit of composite material.

Table 10: Analysis of Composite Road Divider

Sr.No.	Total Deformation	Equivalent Stress	Equivalent Elastic Strain
1	0	0	0
2	105.34	4.9705	0.00061292
3	237.02	11.184	0.0013791

The above results have been evaluated and compared with the hollow concrete road divider, which is not mainly used but can be suggested instead of a composite road divider. For a concrete road barrier, we have created a CAD model. Aligning with previous literature, such as (Klasztorny et al., 2019), who modelled and simulated crash tests on curved barriers considering vehicle speed limits and (Wang et al., 2018), who conducted crash analyses of composite car bodies. The study provides a comprehensive understanding of road divider performance.

The static study conducted before the impact force analysis used four impact forces. We obtained findings for total deformation, equivalent strain, and equivalent stress using Ansys software for static analysis.

As a result, we can carry out further research. We will use solid and hollow objects to analyse the road divider's impact force. After completing the analysis and study for the composite and actual material, we discovered that the composite material exhibits superior deformation and

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better stress concentration. Composite materials include alternatives to genuine and traditional concrete and plastic road dividers.

Table 11: Analysis of Hollow Concrete Road Divider

Sr. No	Total Deformation (mm)	Total Equivalent Stress (MPa)	Equivalent Elastic Strain
1	0	0.0559	0
2	32.157	0.0689	4.2465e-5
3	72.353	1.2956	9.5547e-5

Therefore, it can be concluded that the proposed model can significantly improve the current conditions and outcomes of vehicle impacts with road dividers. This model will also help reduce the damage caused by accidents. According to Table 5.2, the stress induced in hollow concrete road dividers is significantly lower than in composite road dividers. Thus, it is also recommended that hollow concrete road dividers be considered for use. However, composite road dividers, flexible and sustainable with high impact force capacity, are recommended as a superior alternative to concrete road dividers.

Cost comparison for concrete and composite road divider

However, as a rough estimate, here are some cost data in Indian Rupees (INR) for aleaf spring with the following specifications:

Length (L): 650mm Width (b): 900mm Thickness (w): 200mm concrete road divide:

Assuming the Concrete used is a standard road divider, the cost can range from INR750 to INR 2500 per kg. For a road divider of the above dimensions, the weight would be around 35kg to 45 kg, resulting in a cost of around INR 1000 to INR 5500.
Road divider of e-glass & resin composite:

The cost of e-glass and resin materials can vary depending on the quality and manufacturing process. It can range from INR 400 to INR 700 per kg as a rough estimate. For a road divider of the above dimensions, the weight would be around 4 to 5 kg, resulting in a cost of around INR 1000 to INR 2500.

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Table 12: Cost comparison of concrete and composite material

Parameter	Concrete road divider	Composite Road divider	Difference
Weight	40 kg	4 kg	**10 %**
Strength	40 MPa	150 MPa	**36 %**
Cost	5500 INR	2500 INR	**22%**

CONCLUSION

The composite road divider has a high impact strength, is lightweight, and issimple to operate. Comparative studies between epoxy and polyester resins report that epoxy polymer concrete has far superior mechanical properties and durability. It has been reported that adding glass fibres improves the post-peak behaviour of polymer concrete. The strength and toughness of polymer concrete also increase with adding fibres. The researchers have used various aggregate materials, most based on the choice of locally available materials to reduce the cost.

The literature suggests that road dividers significantly improve traffic safety by reducing road accidents and improving driver behaviour. They also improve pedestrian safety and canreduce traffic congestion. These findings highlight the importance of road dividers as a key element of road safety infrastructure.

The studies reviewed in this literature review provide evidence that roaddividers effectively reduce road accidents, fatalities, and injuries. Concrete barriers were the most effective type of road divider, followed by steel, cable, plastic, and guardrail barriers. Road dividers are an Important safety measure that can improve road safety and reduce the number of accidents, fatalities, and injuries on roads.

Composite materials offer excellent durability and resistance to corrosion, weathering, and chemical damage, making them ideal for manufacturing road dividers. They can also withstand harsh environmental conditions, reducing maintenance costs. Composites also offer high-impact resistance, enhancing road safety.

Composite materials' flexibility in design and manufacturing allows for customisable dividers that fit specific traffic conditions. Their durability and low maintenance requirements offer long-term cost-effectiveness despite higher upfront costs.

The ease of manufacturing and customisation also contribute to efficient production processes.

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As technology advances, composite road dividers can be integrated with smart features, improving traffic flow and safety.

Future Research

Future research on composite road dividers is promising as they offer several advantages over traditional materials. Composite materials are engineered by combining two or more materials to create a new material with improved properties. Composites can enhance durability, flexibility, and cost-effectiveness when applied to road dividers. The scope of the work is to provide a static and dynamic analysis of the compositeroad divider.

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