ANALYTICAL STUDY OF BRIDGE BEAM UNDER EXTERNAL LOADING

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1. Summary

In the realm of bridge construction, Reinforced Concrete (RCC) girders stand as critical structural components, bearing the weight of the bridge deck while efficiently channelling diverse loads to the substructure. Renowned for their resilience, extended service life, and cost-effectiveness in bridge engineering, these girders form the cornerstone of our comprehensive investigation. Our study revolves around the meticulous development of three-dimensional finite element models for simply supported girders, embracing different cross-sectional shapes (Rectangular, T-section, and I-sections) within the ANSYS software platform. These meticulously designed models harness both solid and shell elements available in the ANSYS library. Our analysis encompasses a spectrum of concrete grades and diverse loading scenarios, all while maintaining a uniform temperature. Through a meticulous exploration of physical behaviours, including stress, strain, and deformation, we engage in a rigorous comparative assessment of these distinct models.

Our findings distinctly showcase that the I-section girder outperforms the other geometries in terms of stress and strain values. On the other hand, the T-section girder emerges as exceptional in deformation characteristics. Notably, our study highlights the advantageous outcomes achieved through the application of high-strength concrete grades. This valuable insight equips structural engineers and designers with essential guidance for selecting the most suitable cross-sectional shapes and concrete grades, meticulously tailored to the unique demands of specific applications.

This research carries implications extending beyond the realm of girders; it contributes to a broader understanding of structural performance and optimization strategies in bridge engineering. By delving into the intricate interplay of geometry, material properties, and loading conditions, our study offers valuable insights into enhancing the efficiency, resilience, and overall performance of bridge components. It's imperative to acknowledge that the selection of optimal structural configurations and

material grades directly influences not only the immediate safety and reliability of the bridge but also its long-term durability and economic viability.

In essence, our investigation stands as a beacon for evidence-based decision-making in bridge design, aligning engineering excellence with the pragmatic aspects of construction and sustainability. By shedding light on the nuanced advantages offered by specific girders and high-strength concrete grades, we contribute to the evolution of best practices in bridge engineering, ultimately leading to safer, more efficient, and enduring bridge structures that positively impact communities and transportation networks.

Key words: Bridge Girders; FEM; ANSYS; Different Girder Section; External Loading

2. Introduction:

"Bridges: Fostering Unity and Triumphing Over Obstacles" Bridges assume a pivotal role in the domain of civil engineering, acting as vital structures that forge connections among communities, streamline transportation networks, and conquer formidable geographical barriers. These impressive feats of construction span across water bodies, traverse deep valleys, and weave through bustling road networks, facilitating the uninterrupted movement of people, vehicles, and valuable cargo. Across the tapestry of history, bridges have evolved into symbols of human ingenuity and advancement, embodying the continuous progress of engineering and architectural achievements.

Varying in form and size, bridges are meticulously crafted to fulfil precise needs and adapt to the unique surroundings they traverse. From the time-honoured stone arch bridges to modern marvels constructed from steel and concrete, each type of bridge is meticulously engineered to withstand specific loads, environmental forces, and even artistic considerations. Serving as indispensable components of transportation infrastructure, bridges play a substantive role in propelling economic prosperity, regional growth, and the cultivation of cultural interconnections.

Amidst their diverse array, all bridges share a fundamental purpose: to establish links between two points, creating pathways for human interaction and development. Nevertheless, their designs and structural elements exhibit notable variations, influenced by factors such as span length, topographical characteristics, traffic density, and the availability of construction materials. Within the kaleidoscope of bridge typology, "bridge girders" emerge as one of the most critical and widely employed components.

The significance of bridge girders resides in their pivotal role as load-bearing elements, ensuring the stability and integrity of the overall bridge structure. These elongated structural members, often supporting the deck, play a crucial part in absorbing and distributing the loads exerted by traffic, environmental forces, and other external factors. The selection of the appropriate bridge girder design depends on the specific demands of the bridge, aligning with factors such as span length, intended use, structural aesthetics, and available construction materials.

In essence, bridge girders symbolize the intricate fusion of engineering principles with the artistry of design, demonstrating the harmonious convergence of functionality and aesthetics within the realm of civil infrastructure. Through meticulous engineering and innovative design, bridge girders not only bolster the safety and reliability of bridges but also contribute to the visual allure of these essential structures that span our landscapes, connecting communities and carving paths for progress.

3. BRIDGE GIRDERS: The Backbone of Structural Integrity

"Bridges: Enabling Connectivity and Surmounting Challenges" Bridges stand as pivotal features in the realm of civil engineering, functioning as vital structures that foster cohesion among communities, streamline transportation networks, and conquer geographical barriers. These remarkable edifices stretch across waterways, traverse deep valleys, and weave through bustling road networks, facilitating the seamless flow of people, vehicles, and commodities. Throughout the annals of history, bridges serve as testaments to human innovation and progress, showcasing the ever-evolving achievements in engineering and architectural prowess.

Bridges come in a myriad of forms and sizes, meticulously tailored to fulfill specific requirements and adapt to the prevailing surroundings. From ancient stone arch bridges to contemporary marvels crafted from steel and concrete, each bridge type is meticulously engineered to endure distinct loads, environmental forces, and even artistic considerations. As indispensable constituents of transportation infrastructure, bridges significantly contribute to economic vitality, regional expansion, and the fostering of cultural interconnectedness.

Amidst their rich diversity, all bridges share a fundamental purpose: to establish connections between two points, forging pathways for human interaction and progress. However, their designs and structural elements exhibit a wide array of variations, influenced by factors such as span length, terrain characteristics, traffic density, and the spectrum of available construction materials. Among the diverse range of bridge types, "bridge girders" emerge as a cornerstone, constituting one of the most essential and widely employed components.

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4. ABOUT THE SOFTWARE

"ANSYS: A Catalyst for Engineering Excellence and Problem Solving" ANSYS, developed by ANSYS Inc., emerges as a formidable and extensively utilized suite of simulation software that has earned acclaim for its adeptness in tackling intricate engineering dilemmas across diverse industries. Its abbreviated moniker, which stands for "Analysis System," serves as a comprehensive platform bestowing engineers and researchers with the means to engage in finite element analysis (FEA), computational fluid dynamics (CFD), electromagnetic simulations, and a spectrum of other advanced simulations.

Through ANSYS, users wield the power to meticulously analyse and refine product designs, evaluate performance under a myriad of conditions, and replicate real-world scenarios without the necessity of physical prototypes. This software embraces a wide array of engineering disciplines, encompassing structural analysis, heat transfer, fluid dynamics, acoustics, and electromagnetics.

A standout attribute of ANSYS lies in its expansive repository of pre-defined elements and materials, facilitating the precise emulation of real-world structures and systems. Furthermore, ANSYS encompasses a suite of solvers and algorithms adept at navigating complex physics and nonlinear behaviours, rendering it suitable for dissecting both straightforward and intricately woven engineering conundrums.

ANSYS takes a deliberate approach to ensure that its user interface remains accessible to both seasoned engineering professionals and those at the outset of their journey. The software offers interactive tools for model creation, mesh generation, analysis setup, and post-processing of results, rendering the simulation process an intuitive endeavour.

The applicability of ANSYS extends across diverse sectors, including aerospace, automotive, civil engineering, electronics, and biomedical, among others. Engineers leverage ANSYS to fine-tune product designs, elevate performance benchmarks, curtail costs, and fortify safety standards.

In summation, ANSYS upholds its standing as a pivotal instrument in the realm of engineering simulations, empowering engineers and researchers alike to craft well-founded decisions grounded in accurate and exhaustive analyses. Its versatile nature, robust capabilities, and user-centric interface solidify it as indispensable software, propelling engineering innovation and providing effective resolutions to formidable engineering challenges.

5. PROPERTIES OF MATERIALS AND SECTIONS

- The forthcoming analysis entails a thorough exploration of the distinct characteristics inherent in two concrete grades: M50, representing standard strength, and M60, emblematic of high strength. This meticulous investigation holds significant importance as it unveils vital insights into the material properties of these concrete variants, enabling a deeper comprehension of their behaviours under diverse conditions.

- The inclusion of both standard and high-strength concrete grades adds a profound layer of complexity to our inquiry. By encompassing these diverse materials, we are poised to uncover a nuanced understanding of how concrete responds to external factors, encompassing load distribution, deformation, and stress. This knowledge not only enriches our understanding of concrete behaviours but also carries profound implications for engineering applications and design considerations.

- The selection of material properties stands as a pivotal element in ensuring the real-world relevance of our analysis. While our primary focus revolves around the distinctive traits of M50 and M60 concrete, it's essential to recognize that the approach we employ holds the potential for extrapolation to other concrete grades. This versatility makes our study a valuable resource, capable of benefiting a broader spectrum of engineering contexts.

• In the grand scheme, this exhaustive exploration of material properties within M50 and M60 concrete grades propels us toward a more holistic grasp of their structural performance. The invaluable insights derived from this analysis not only enrich our knowledge reservoir but also contribute to making more informed decisions in the realms of material selection and design optimization. By doing so, we elevate the standards of quality, safety, and operational efficiency across a myriad of construction projects.

1. Material properties for M50 grade concrete:

- Young’s Elasticity: 35,355.33906 Mpa
- Poisson’s Ratio: 0.2
- Temperature Expansion Coefficient : 0.00001334

2. Material properties for M60 grade concrete:

- Young’s Elasticity: 38,729.83346 Mpa
- Poisson’s Ratio: 0.2
- Temperature Expansion Coefficient: 0.000013

3. Reinforcement Physical Properties: The reinforcement material used is Fe-500, with the following properties:

- Young’s Elasticity: 210 Gpa
- Poisson’s Ratio: 0.3
- Temperature Expansion Coefficient: 0.0000117

4. Geometric Properties of Slab:

The selected depth for the bridge's deck slab is 80mm per meter length, falling within the range of 80mm to 90mm as determined.

Overall depth = 80*2.77 = 221.6 =230mm, Wearing coat thickness is taken (WC) = 80mm

5. Geometric Properties of Girder Beams:

The depths of the girders are standardized at 60mm per meter length. Here are the dimensions for each type of girder:

1. Rectangular Beam:

Main girder: Overall depth = 900 mm, Overall width = 600 mm

Cross girder: Overall depth = 500 mm, Overall width = 350 mm

2. T-Beam Girder:

Main girder: Overall depth = 900 mm, Overall width = 600 mm

Flange width = 2440 mm, depth = 230 mm

Web width = 600 mm, depth = 670 mm

3. I-Beam Girder:

Main girder: Overall depth = 900 mm, Overall width = 600 mm

Top Flange width = 2440 mm, depth = 230 mm

Bottom Flange width = 1000 mm, depth = 150 mm

Web width = 200 mm, depth = 520 mm

7. MODELING AND ANALYSIS:

This research employs the powerful ANSYS software to conduct an extensive nonlinear analysis, with the primary objective of deeply understanding the dynamic behaviours of a specific beam section. The focus here is to expose the beam to a diverse range of loads, meticulously replicating real-world conditions. This well-structured methodology, fortified by the computational capabilities of ANSYS, aims to extract a wealth of invaluable data, diligently capturing the intricate interplay of deformation, stress distribution, strain patterns, and the pivotal bending moments experienced by the beam section across this comprehensive load spectrum.

By effectively harnessing the versatile capabilities of the ANSYS software, this research aspires to unveil profound insights into the structural response of the beam section. The analytical endeavour aims to unravel how the beam section transforms and perseveres in the face of multifaceted challenges posed by these varying loads. In doing so, it illuminates the underlying mechanics and intricate behaviours that govern the beam's resilience and performance.

This quest for understanding, facilitated by ANSYS, holds the potential to yield a comprehensive dataset that goes beyond superficial observations. Its aim is to unravel the intricate interplay between forces and structural elements, thereby illuminating the concealed dynamics that shape the beam section's reaction to the complex array of load scenarios it encounters. The abundance of data garnered through this rigorous method holds the capacity to drive precise engineering decisions across diverse domains—be it in the realm of design refinement, optimization, or ensuring the safety and long-term durability of structures subjected to a spectrum of external forces.

In essence, the ANSYS-driven nonlinear analysis, seamlessly integrated into the fabric of this research, serves as a bridge connecting the theoretical realm with empirical reality. This analytical approach provides a distinctive lens through which we can peer into the fundamental behaviours of the beam section, cultivating a more profound comprehension of its intricate response to the dynamic real-world forces that it inevitably confronts. This study, woven together by ANSYS, stands as a testament to the potent synergy between advanced simulation tools and inquisitive exploration, yielding insights that navigate the intricate contours of structural behaviours.

7.2. Procedure for Modelling:

Constructing a comprehensive structural model of a beam bridge for in-depth analysis using the ANSYS software involves a carefully orchestrated sequence of steps. Let's embark on this journey:

1. Geometry Creation:

Begin by designing the 3D geometry of the beam bridge, utilizing either ANSYS Design Modeller or a compatible CAD software. This phase requires precise definition of the bridge's dimensions, cross-sections, and foundational supports, serving as the foundational blueprint.

2. Material Properties:

Pay meticulous attention to assigning accurate material properties to the diverse components of the bridge. Focus on defining material characteristics for both concrete and steel elements, including critical parameters such as Young's elasticity, Poisson's Ratio, and the temperature expansion coefficient. These properties form the foundation for capturing the intricate behaviours of the bridge under diverse environmental conditions.

3. Meshing:

Create a suitable mesh tailored to the intricate geometry of the bridge, using ANSYS Meshing capabilities. The chosen element size must accurately capture the nuanced structural behaviours. For intricate structures, it's advisable to incorporate both solid and shell components into the mesh, improving the accuracy of the model.

4. Boundary Conditions:

Apply appropriate boundary conditions to the bridge model. Fix the supports to mirror the foundation of the bridge, effectively constraining any potential movements or rotations at these pivotal support points.

5. Loading:

Apply external loads to the bridge model based on the specified analysis scenario. Consider a diverse array of load types, from conventional dead loads and imposed loads to temperature loads, wind loads, and even seismic forces, aligned with the unique demands of the analysis.

6. Nonlinear Analysis Setup:

Set up a nonlinear analysis within ANSYS, considering the nature of applied loads and the nuanced behaviours of materials. If significant deformations are expected, incorporate geometric nonlinearity. Define material properties for both concrete and steel, encompassing nonlinear behaviours, including plasticity.

7. Solver Options:

Choose the most suitable solver for the specific analysis at hand, such as Mechanical APDL, Workbench Mechanical, or the capabilities of Explicit Dynamics, particularly relevant for dynamic loading. Configure convergence criteria and solver options for reliable results.

8. Analysis:

Execute the analysis within the ANSYS environment, closely monitoring solution convergence. Respond promptly to any emerging warnings or errors, ensuring the stability and accuracy of the process.

9. Post-processing:

After the analysis, use ANSYS Post-processing tools to meticulously review the results. Visualize and analyse the deformation, stress, strain, and bending moments experienced by the bridge structure, which holds significant importance.

10. Interpretation of Results:

Thoroughly interpret the outcomes to evaluate the safety, performance, and overall behaviours of the beam bridge under external loading. Identify critical areas, stress concentrations, and potential failure modes based on the analysis results.

11. Optimization:

If necessary, consider optimizing the model or adjusting material properties based on the analysis results. Aim to refine the bridge's design for enhanced performance and increased safety margins.

This meticulous adherence to a well-structured sequence of steps allows us to effectively create a sophisticated beam bridge model within the ANSYS software, delving deep into its response to a wide range of external loading scenarios. This endeavour, rich with valuable insights, forms the foundation of engineering decisions, cementing the structural integrity and unwavering safety of the beam bridge.

8. EXTERNAL LOADS CONSIDERED BRIDGE BEAM ANALYSIS

Following are the various loads involved in the design procedure:

1. Self-Load (SL)

2. Imposed Load (IL)

3. Impact Load (IPL)

4. Longitudinal Force (LF)

5. Wind Load (WL)

6. Centrifugal Force (CF)

7. Up thrust Effect (UE)

8. Water Current Influence (WI)

9. Thermal Effects (TE)

10. Earthquake Loads (EL)

INDIVIDUAL LOAD DETAILS				
SLNO	**LOAD NAME**	**LOAD**		
		kN/m2		
		Vertical downward	**Horizontal**	**Vertical upward**
1	SELF LOAD (SL)	26.953		
2	IMPOSED LOAD (IL)	350		
3	IMPACT LOAD (IPL)	114.034		
4	LONGITUDINAL FORCE (LF)	70		
5	WIND LOAD (WL)		0.1905	
6	CENTRIFUGAL FORCES (CF)		76.553	
7	UP THRUST EFFECT (UE)			119.58
8	WATER CURRENT INFLUENCE (WC)			1.49E-03
9	EARTHQUAKE LOADS (EL)			2E-21

9. NUMERICAL RESULTS:

SPAN -15m, @M50 GRADE @ TEMP. : 38.3°C (constant)

SLNO	BEAM SECTION	DIRECTIONOF LOAD	TYPE OF LOAD	LOAD kN/m2	DEFORMATION IN mm	STRESS kN/m2	STRAIN	BENDING MOMENT kN/m2	
1	RECTANGLE SECTION	DOWNWARD VERTICAL LOADS (T1)	SL+IL+IPL+LF	560.99	78.65	0.89	0.029	49.3E+06	@ SUPPORT
					60.59	0.89	0.029		@ MID SPAN
		HORIZONTAL LOAD (T2)	T1+WL	561.18	78.65	0.89	0.029	49.3E+06	@ SUPPORT
					60.59	0.89	0.029		@ MID SPAN
			T1+WL +CF	637.73	78.71	0.89	0.029	49.4E+06	@ SUPPORT
					60.65	0.89	0.029		@ MID SPAN
		UPWARD VERTICAL LOADS (T3)	T1+UE	680.57	78.65	0.89	0.029	49.3E+06	@ SUPPORT
					60.59	0.89	0.029		@ MID SPAN
			T1+WC	560.99	78.65	0.89	0.029	49.3E+06	@ SUPPORTS
					60.59	0.89	0.029		@ MID SPAN
			T1+ EL	560.99	78.65	0.89	0.029	49.3E+06	@ SUPPORT
					60.59	0.89	0.029		@ MID SPAN

SPAN -15m, @M60 GRADE @ TEMP. : 38.3°C (constant)

SLNO	BEAM SECTION	DIRECTION OF LOAD	TYPE OF LOAD	LOAD kN/m2	DEFORMATION IN mm	STRESS kN/m2	STRAIN	BENDING MOMENT kN/m2	
2	RECTANGLE SECTION	DOWNWARD VERTICAL LOADS (T1)	SL+IL+IPL+LF	560.99	75.29	0.91	0.027	49.3E+06	@ SUPPORT
					58.24	0.91	0.027		@ MID SPAN
		HORIZONTAL LOAD (T2)	T1+WL	561.18	75.29	0.91	0.027	49.3E+06	@ SUPPORT
					58.24	0.91	0.027		@ MID SPAN
			T1+WL +CF	637.73	75.36	0.904	0.027	49.4E+06	@ SUPPORT
					58.30	0.904	0.027		@ MID SPAN
		UPWARD VERTICAL LOADS (T3)	T1+UE	680.57	78.65	0.89	0.029	49.3E+06	@ SUPPORT
					60.59	0.89	0.029		@ MID SPAN
			T1+WC	560.99	75.29	0.905	0.027	49.3E+06	@ SUPPORTS
					58.24	0.905	0.027		@ MID SPAN
			T1+ EL	560.99	75.29	0.905	0.027	49.3E+06	@ SUPPORT
					58.24	0.905	0.027		@ MID SPAN

SPAN -15m, @M50 GRADE @ TEMP. : 38.3°C (constant)

SLNO	**BEAM SECTION**	**DIRECTION OF LOAD**	**TYPE OF LOAD**	**LOAD kN/m2**	**DEFORMATION IN mm**	**STRESS kN/m2**	**STRAIN**	**BENDING MOMENT kN/m2**	
3	T- SECTION	DOWNWARD VERTICAL LOADS (T1)	SL+IL+IPL+LF	560.99	35.03	0.89	0.030	49.3E+06	@ SUPPORT
					18.87	0.89	0.030		@ MID SPAN
		HORIZONTAL LOAD (T2)	T1+WL	561.18	35.03	0.89	0.030	49.3E+06	@ SUPPORT
					18.87	0.89	0.030		@ MID SPAN
			T1+WL +CF	637.73	35.06	0.89	0.030	49.4E+06	@ SUPPORT
					18.90	0.89	0.030		@ MID SPAN
		UPWARD VERTICAL LOADS (T3)	T1+UE	680.57	35.03	0.89	0.030	49.3E+06	@ SUPPORT
					18.87	0.89	0.030		@ MID SPAN
			T1+WC	560.99	35.03	0.89	0.030	49.3E+06	@ SUPPORTS
					18.87	0.89	0.030		@ MID SPAN
			T1+ EL	560.99	35.03	0.89	0.030	49.3E+06	@ SUPPORT
					18.87	0.89	0.030		@ MID SPAN

SPAN -15m, @M60 GRADE @ TEMP. : 38.3^{o}C (constant)

SLNO	**BEAM SECTION**	**DIRECTION OF LOAD**	**TYPE OF LOAD**	**LOAD kN/m2**	**DEFORMATION IN mm**	**STRESS kN/m2**	**STRAIN**	**BENDING MOMENT kN/m2**	
4	T- SECTION	DOWNWARD VERTICAL LOADS (T1)	SL+IL+IPL+LF	560.99	33.47	0.90	0.028	49.3E+06	@ SUPPORT
					18.29	0.90	0.028		@ MID SPAN
		HORIZONTAL LOAD (T2)	T1+WL	561.18	33.47	0.90	0.028	49.3E+06	@ SUPPORT
					18.29	0.90	0.028		@ MID SPAN
			T1+WL +CF	637.73	33.50	0.90	0.028	49.4E+06	@ SUPPORT
					18.32	0.90	0.028		@ MID SPAN
		UPWARD VERTICAL LOADS (T3)	T1+UE	680.57	33.47	0.90	0.028	49.3E+06	@ SUPPORT
					18.29	0.90	0.028		@ MID SPAN
			T1+WC	560.99	33.47	0.90	0.028	49.3E+06	@ SUPPORTS
					18.29	0.90	0.028		@ MID SPAN
			T1+ EL	560.99	33.47	0.90	0.028	49.3E+06	@ SUPPORT
					18.29	0.90	0.028		@ MID SPAN

SPAN -15m, @M50 GRADE @ TEMP. : 38.3°C (constant)

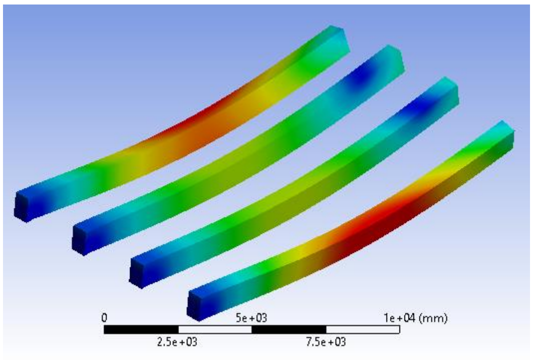
SLNO	**BEAM SECTION**	**DIRECTION OF LOAD**	**TYPE OF LOAD**	**LOAD kN/m2**	**DEFORMATION IN mm**	**STRESS kN/m2**	**STRAIN**	**BENDING MOMENT kN/m2**	
5	I- SECTION	DOWNWARD VERTICAL LOADS (T1)	SL+IL+IPL+LF	560.99	36.84	0.46	0.014	49.3E+06	@ SUPPORT
					25.05	0.37	0.014		@ MID SPAN
		HORIZONTAL LOAD (T2)	T1+WL	561.18	36.84	0.46	0.014	49.3E+06	@ SUPPORT
					25.05	0.37	0.014		@ MID SPAN
			T1+WL +CF	637.73	36.81	0.46	0.014	49.4E+06	@ SUPPORT
					25.03	0.37	0.014		@ MID SPAN
		UPWARD VERTICAL LOADS (T3)	T1+UE	680.57	36.84	0.46	0.014	49.3E+06	@ SUPPORT
					25.05	0.37	0.014		@ MID SPAN
			T1+WC	560.99	36.84	0.46	0.014	49.3E+06	@ SUPPORTS
					25.05	0.37	0.014		@ MID SPAN
			T1+ EL	560.99	36.84	0.46	0.014	49.3E+06	@ SUPPORT
					25.05	0.37	0.014		@ MID SPAN

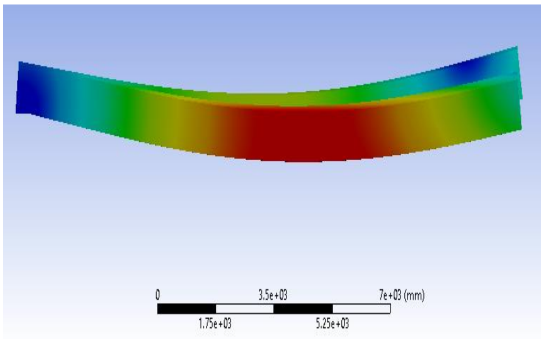
SPAN -15m, @M60 GRADE @ TEMP. : 38.3°C (constant)

SLNO	BEAM SECTION	DIRECTION OF LOAD	TYPE OF LOAD	LOAD kN/m2	DEFORMATION IN mm	STRESS kN/m2	STRAIN	BENDING MOMENT kN/m2	
6	I- SECTION	DOWNWARD VERTICAL LOADS (T1)	SL+IL+IPL+LF	560.99	35.24	0.47	0.013	49.3E+06	@ SUPPORT
					24.21	0.37	0.013		@ MID SPAN
		HORIZONTAL LOAD (T2)	T1+WL	561.18	35.25	0.47	0.013	49.3E+06	@ SUPPORT
					24.21	0.37	0.013		@ MID SPAN
			T1+WL +CF	637.73	35.22	0.47	0.013	49.4E+06	@ SUPPORT
					24.19	0.37	0.013		@ MID SPAN
		UPWARD VERTICAL LOADS (T3)	T1+UE	680.57	35.24	0.47	0.013	49.3E+06	@ SUPPORT
					24.21	0.37	0.013		@ MID SPAN
			T1+WC	560.99	35.24	0.47	0.013	49.3E+06	@ SUPPORTS
					24.21	0.37	0.013		@ MID SPAN
			T1+ EL	560.99	35.24	0.47	0.013	49.3E+06	@ SUPPORT
					24.21	0.37	0.013		@ MID SPAN

10. ANSYS RESULTS

RECTANGLE SECTION





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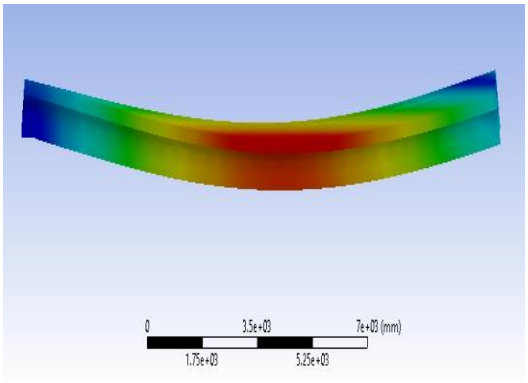

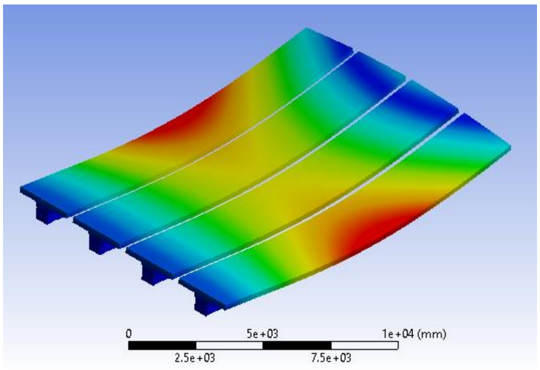

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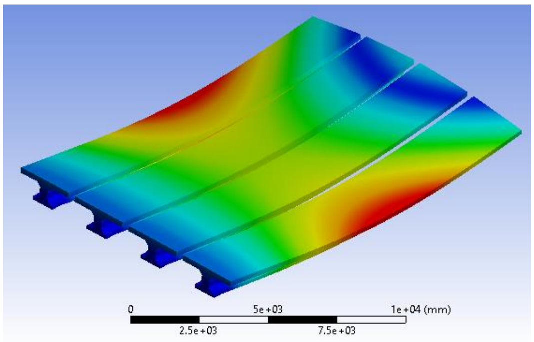
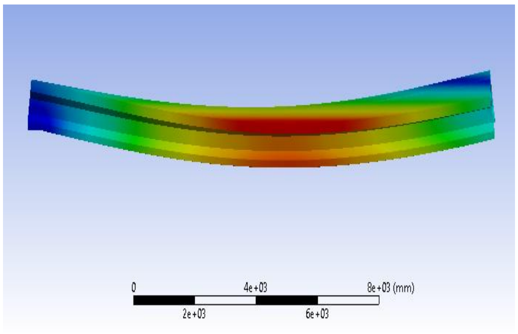
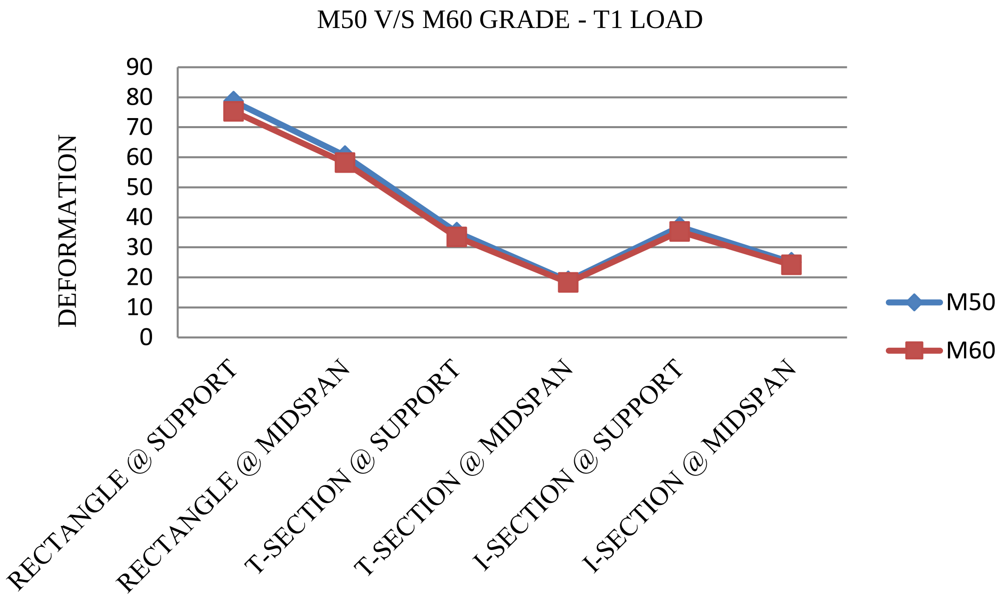
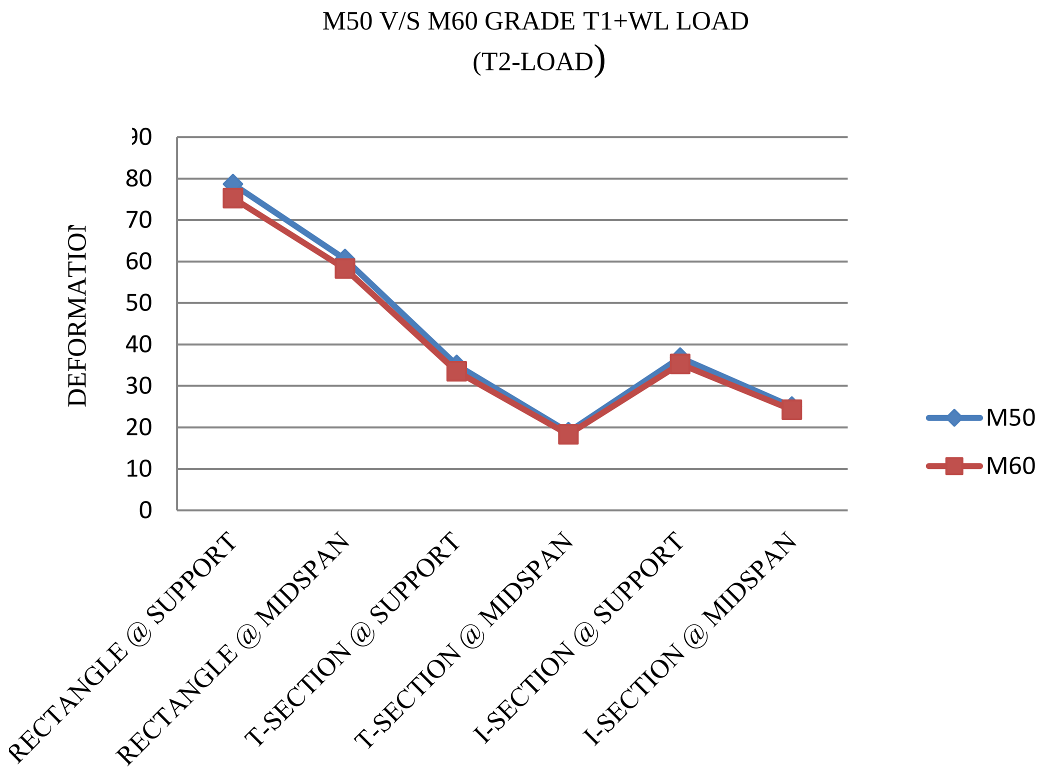
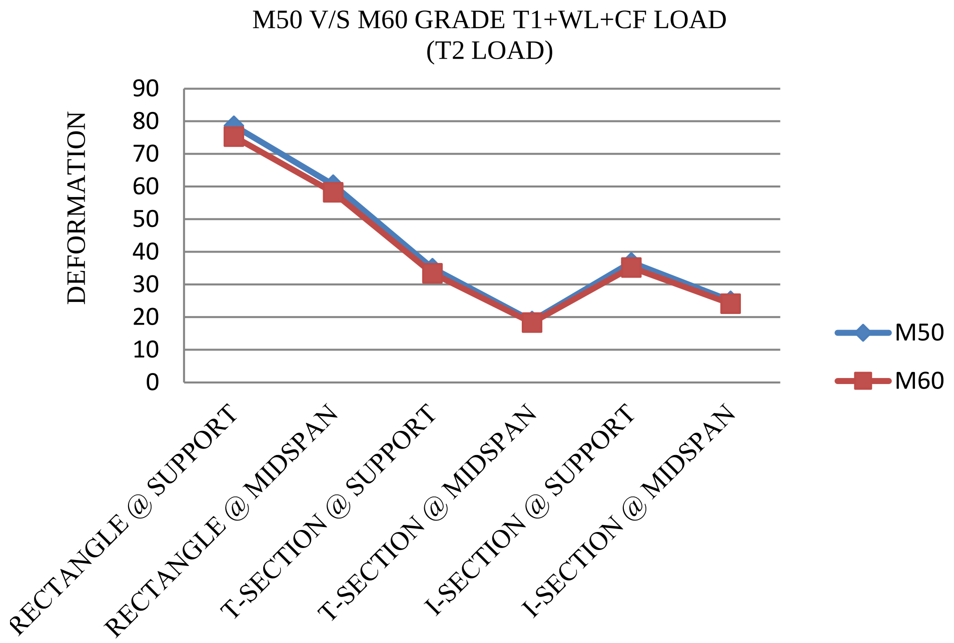
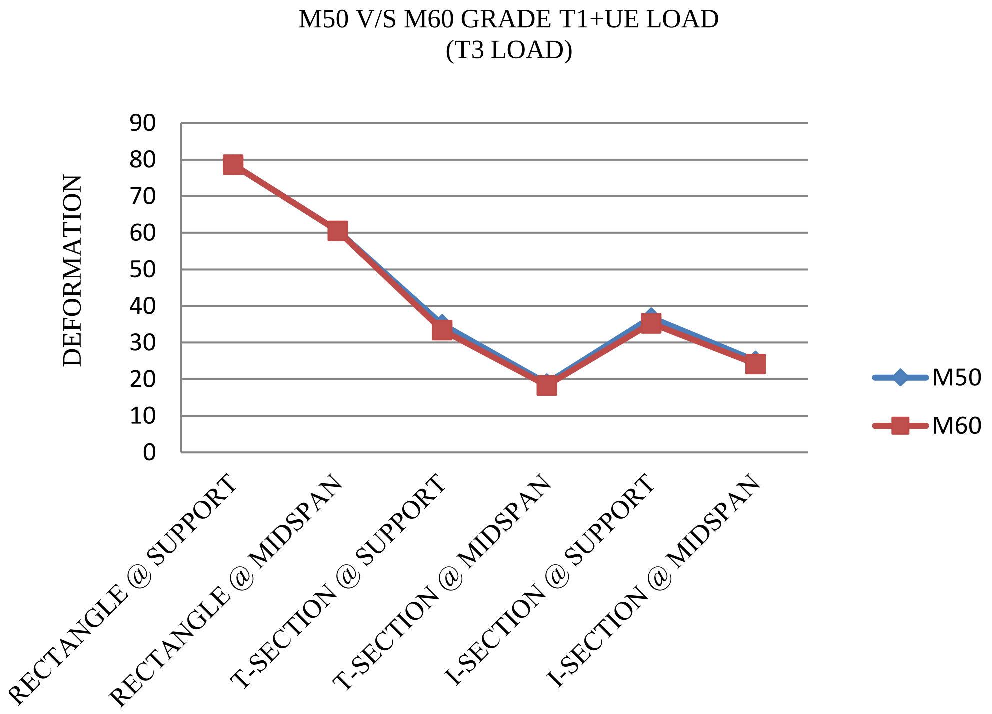


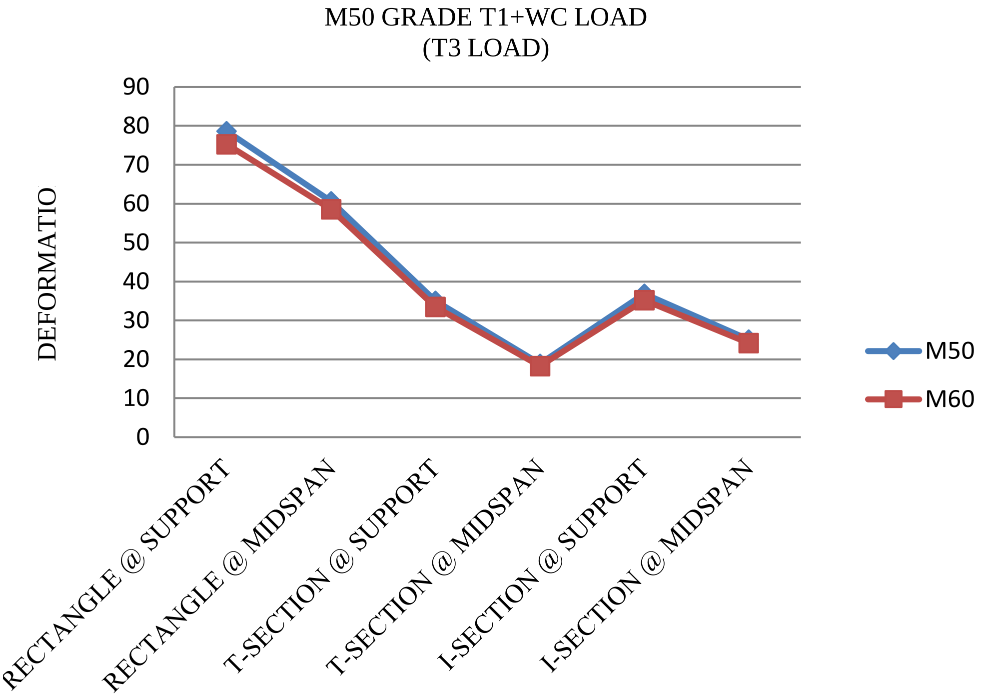


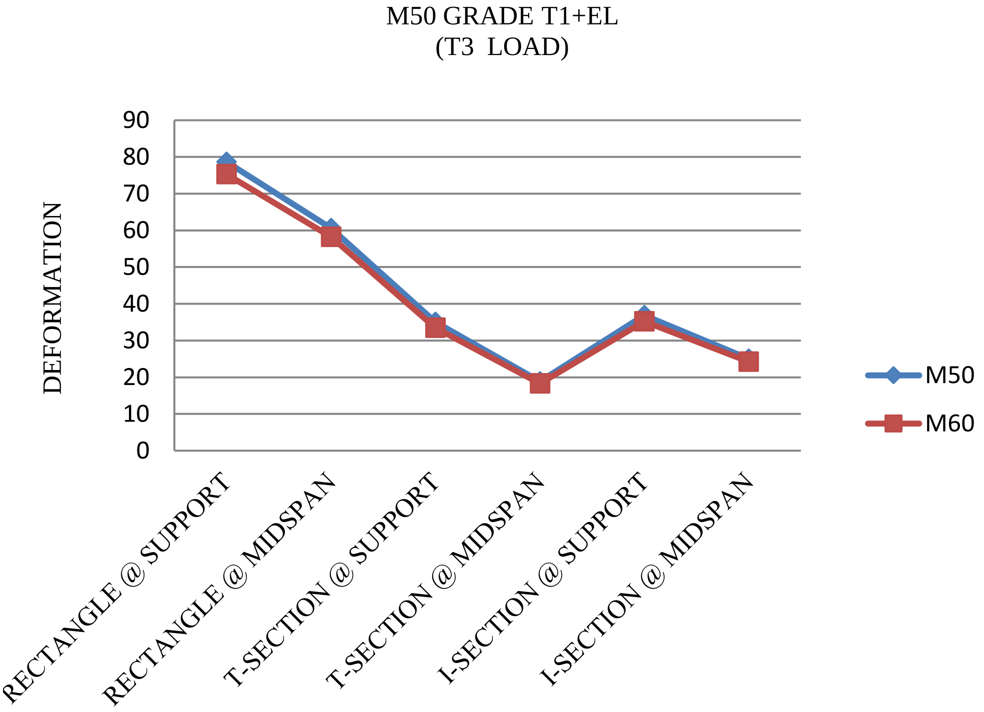

M50 V/S M60 GRADE - T1 LOAD

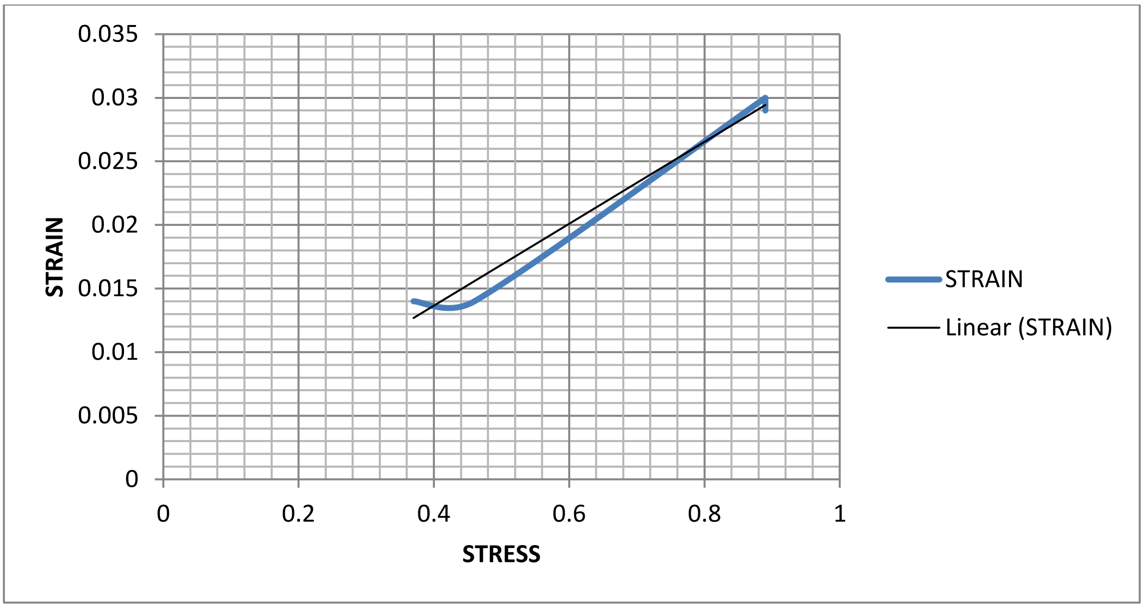

M50 V/S M60 GRADE T1+WL LOAD
(T2-LOAD)


M50 V/S M60 GRADE T1+WL+CF LOAD
(T2 LOAD)
DEFORMATION
90
80
70
60
50
40
30
20
10
0
RECTANGLE @ SUPPORT
RECTANGLE @ MIDSPAN
T-SECTION @ SUPPORT
T-SECTION @ MIDSPAN
I-SECTION @ SUPPORT
I-SECTION @ MIDSPAN
M50
M60


M50 V/S M60 GRADE T1+UE LOAD
(T3 LOAD)
DEFORMATION
90
80
70
60
50
40
30
20
10
0
RECTANGLE @ SUPPORT
RECTANGLE @ MIDSPAN
T-SECTION @ SUPPORT
T-SECTION @ MIDSPAN
I-SECTION @ SUPPORT
I-SECTION @ MIDSPAN
M50
M60

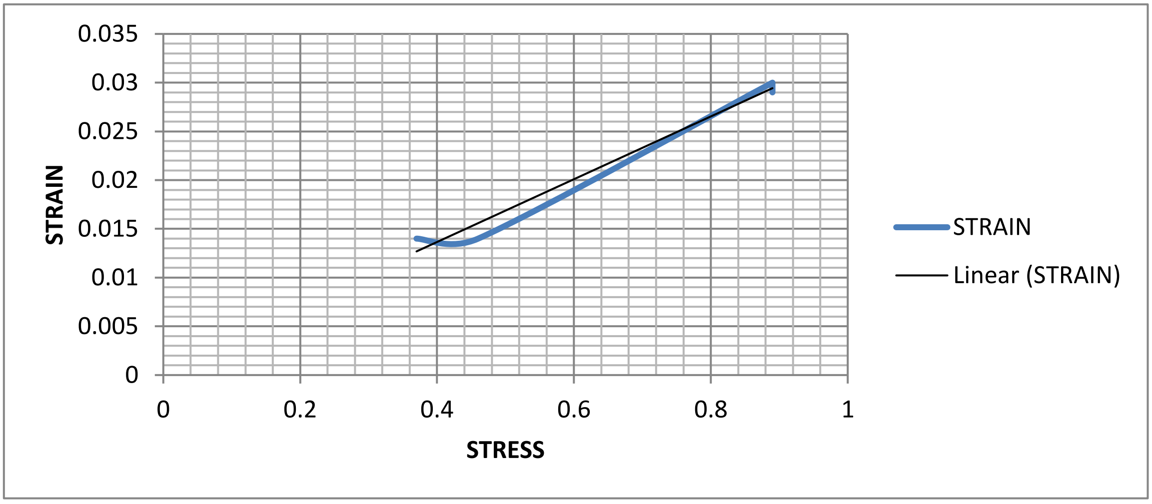

M50 GRADE T1+WC LOAD
(T3 LOAD)
DEFORMATIO
90
80
70
60
50
40
30
20
10
0
RECTANGLE @ SUPPORT
RECTANGLE @ MIDSPAN
T-SECTION @ SUPPORT
T-SECTION @ MIDSPAN
I-SECTION @ SUPPORT
I-SECTION @ MIDSPAN
M50
M60


M50 GRADE T1+EL
(T3 LOAD)
DEFORMATION
90
80
70
60
50
40
30
20
10
0
RECTANGLE @ SUPPORT
RECTANGLE @ MIDSPAN
T-SECTION @ SUPPORT
T-SECTION @ MIDSPAN
I-SECTION @ SUPPORT
I-SECTION @ MIDSPAN
M50
M60



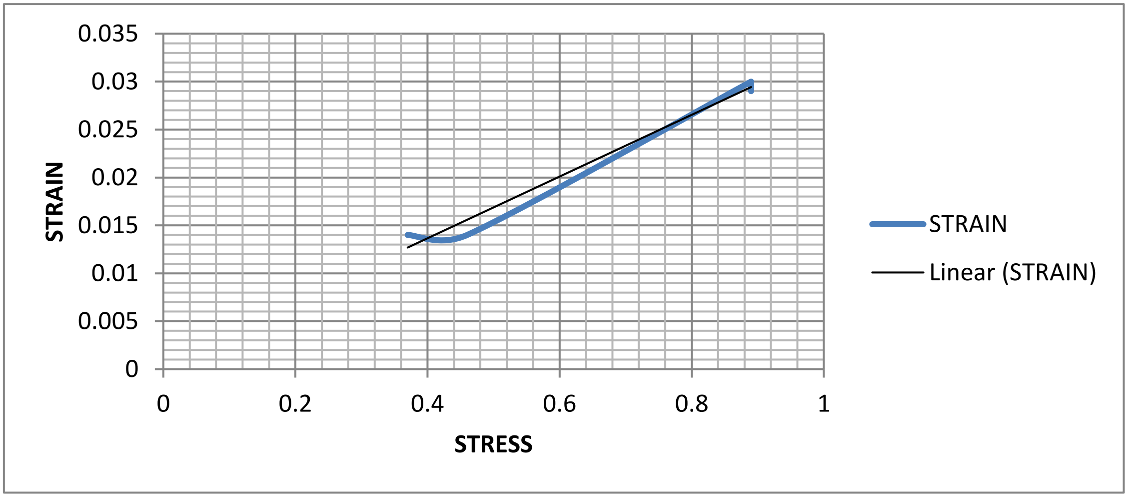
M50 GRADE

Stress-Stain curve against T1-Load

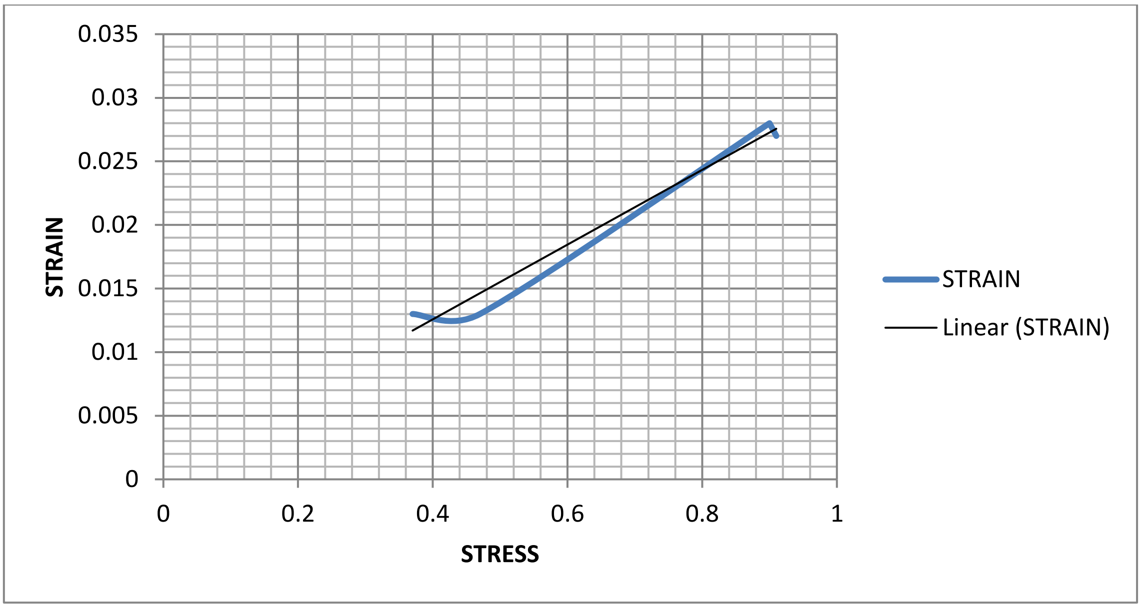


M50 GRADE

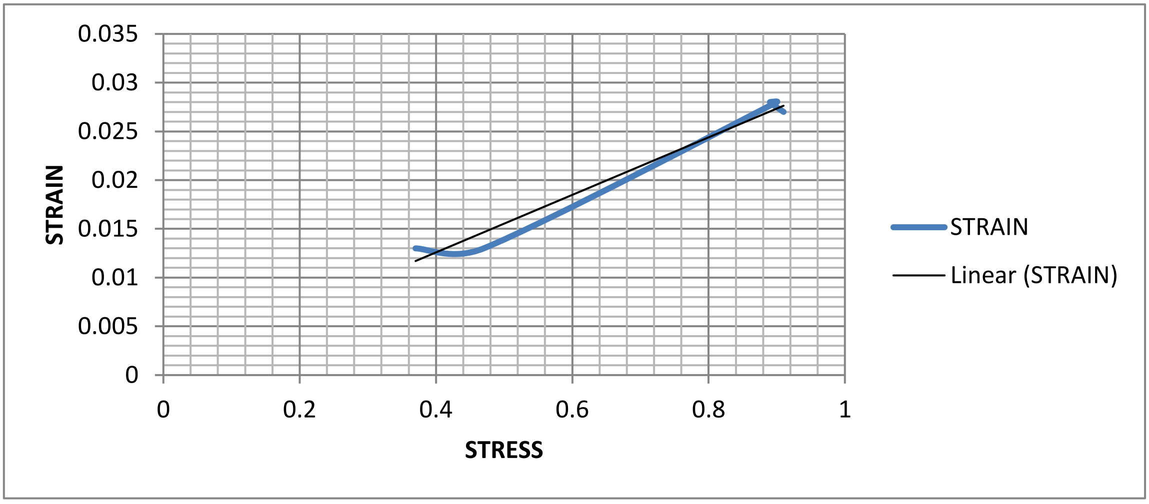
Stress-Stain curve against T1+WL+CF (T2-Load)



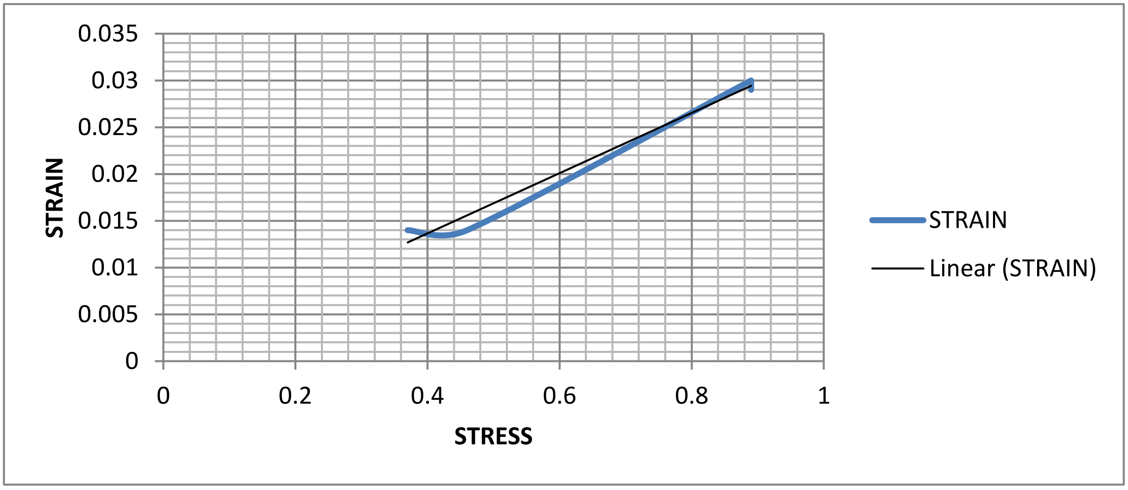
M50 GRADE Stress-Stain curve against T1+UE, WC & EL (T3-Load)



M60 GRADE Stress-Stain curve against T1-Load



M60 GRADE Stress-Stain curve against T1+WL+CF (T2-Load)



M60 GRADE Stress-Stain curve against T1+UE, WC & EL (T3-Load)

10. CONCLUSION:

1. The meticulous finite element analysis (FEA) conducted utilizing ANSYS software has unveiled a compelling revelation: the T-section girder exhibits markedly superior deformation resistance when subjected to identical external loading conditions, as thoroughly demonstrated within the scope of this study.

2. This remarkable capability of the T-section girder in withstanding deformation can be traced back to its distinctively crafted cross-sectional shape. This unique design attribute equips it with an enhanced capacity to counteract external loading forces, culminating in a level of performance that sets it apart from its counterparts.

3. A significant turning point in the investigation arises from the decision to elevate the concrete grade from M50 to M60. This deliberate alteration notably elevates the strength of the girder, consequently leading to a tangible reduction in deformation when juxtaposed with the M50 girder—a substantial and noteworthy outcome that enriches the findings of this study.

4. The stress and strain levels encountered in both the Rectangle and T-sections display a remarkable similarity when subjected to the same concrete grade. Intriguingly, the I-section emerges as the standout performer, registering an approximate 50% reduction in both stress and strain when compared against the other sections—a pivotal discovery that holds profound implications for our understanding of structural dynamics and design considerations.

11. REFFERENCE:

1. In the academic landscape of 1994, a thorough investigation was led by the collaborative minds of Chang and Lee. Their ground breaking study, titled "Impact Factors for Simple-Span Highway Girder Bridges," found its place within the esteemed Journal of Structural Engineering, a hallmark of the American Society of Civil Engineers (ASCE). The illuminating insights from this work can be discovered in Volume 120, Issue 3, spanning pages 704 to 715, offering a comprehensive exploration into the intricacies of highway girder bridges.

2. On the notable date of November 17, 2022, a dedicated team, consisting of Duc Cong Nguyen, Marek Salamak, Andrzej Katunin, and Michael Gerges, embarked on a captivating endeavour. Their intriguing case study, aptly titled "Finite Element Model Updating of RC Bridge Structure with Static Load Testing: A Case Study of the Vietnamese Thi-Thac Bridge in Coastal and Marine Environment," was unveiled on

the distinguished academic platform of MDPI. This comprehensive research delves into the intricate dynamics of bridge structures, advancing our understanding of their behavior within the challenging context of coastal and marine environments.

3. Amid the academic tapestry of May 2017, a diligent scholar named Jayakrishnan, hailing from the esteemed Sree Narayana Institute of Technology in Theppupara, Adoor, and Kerala, stood as the author of a significant paper. The title, "Analysis of Seismic Behaviour of a Composite Bridge using ANSYS," graced the respected pages of the International Journal of Engineering Research and Technology (IJERT). Jayakrishnan's contribution expanded our knowledge in the domain of seismic resilience, shedding light on the intricate interactions between composite bridges and dynamic forces.

4. In the quest for understanding the intricate interplay of coastal environments, Riyadh Alsultani, Ibtisam R. Karim, and Saleh I. Khassaf embarked on an extensive inquiry. Their tireless efforts culminated in a comprehensive investigation titled "Dynamic Response Analysis of Coastal Piled Bridge Pier Subjected to Current, Wave, and Earthquake Actions with Different Structure Orientations." This noteworthy research, a culmination of their expertise, found its home within the distinguished pages of the International Journal of Civil Engineering and Science of Materials (IJCSM) on the significant date of January 15, 2023.

5. The year 2022 witnessed the harmonious collaboration of Huang Y, Wang P, Zhao M, Zhang C, and Du X, resulting in a significant publication that carries a substantial impact. Their article, elegantly titled "Dynamic Response of Sea-Crossing Bridge under Combined Seismic and Wave-Current Action," was granted a prominent spot within the reputable pages of Elsevier's Structure Amsterdam. This work enriches our understanding of the complex interactions that sea-crossing bridges face, particularly in the face of the simultaneous challenges posed by seismic and wave-current actions.

6. In the year 1995, the trio of Yang, Y. B., Liao, S. S., and Lin B. H. left an indelible mark in the annals of structural engineering. Their meticulously authored journal article, titled "Impact Formulas for Vehicles Moving over Simple and Continuous Beams," earned its rightful place within the esteemed Journal of Structural Engineering (Vol. 121, No. 11, pp. 1644-1650). Their work, a beacon of insight, explored the dynamic interactions between vehicles and bridge structures, providing essential knowledge for the design and analysis of such critical infrastructure.

7. The year 1992 saw the publication of a noteworthy contribution authored by Wang, T. L., Huang, D., and Shahawy, M. Their journal article, engagingly titled "Dynamic Response of Multi-Girder Bridges," was prominently featured in the respected Journal of Structural Engineering (Vol. 118, No. 8, pp. 2222-2238). Their research, contributing to the understanding of multi-girder bridge behaviour, remains a valuable reference in the realm of structural dynamics.

8. The year 1997 marked the emergence of a significant contribution by the minds of Yang, Y. B., and Yau, J. D. Their journal article, aptly titled "Vehicle-Bridge Interaction Element of Dynamic Analysis," made its mark within the Journal of Structural Engineering (Vol. 123, No. 11, pp. 1512-1518). This work, focused on the intricate interplay between vehicles and bridge structures, adds to our understanding of dynamic analysis techniques, a cornerstone in ensuring the robustness of bridges in the face of real-world conditions.

9. In 2012, a team led by researchers Ding, L., Hao, H., Xia, Y., and Deeks, A. undertook a significant endeavour aimed at assessing the load-bearing capability of bridges. They accomplished this by leveraging an advanced finite element model coupled with the power of nonlinear analysis. The fruits of their labour were shared with the scholarly community through publication in the esteemed journal "Advances in Structural Engineering." This valuable contribution can be found within Volume 15 of the journal, specifically on pages 1739-1750, offering deep insights into the intricate realm of structural engineering.