Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

Analysis and Design of RCC-T Beam Bridge at Aruvikkara using MIDAS

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Abstract

This project focuses on the sustainable design and analysis of a composite Aruvikkara Bridge using MIDAS software. The bridge aims to minimize environmental impact while ensuring structural integrity and safety.The design improves access to the nearby state highway and upcoming ring road, reducing traffic congestion caused by the narrow existing bridge. The project includes a complete structural design and analysis of the new bridge. A manual design is performed for the deck slab to compare with software-based results. The report presents a detailed study of RCC T-beams using both theoretical and software approaches. MIDAS is used to evaluate the stability and performance of the T-beam section. Design calculations and reinforcement details are prepared as per standard codes. The study emphasizes the advantages of T-beams in improving structural strength and efficiency.

Keywords: MIDAS,T-Beam,structural design

1. Introduction

This Bridges are vital components of the road network in both urban and rural areas. With advancements in technology, traditional bridges are being replaced by innovative and efficient structural systems. Among these systems, RCC T-beam and conventional beam frameworks are widely used. Bridge design is a complex process which is mainly considered by some factors such as span length and live loads.These factors play a critical role during the design stage of the design. While designing such selected structural system involves steps like cost, view, and code provisions.

T-beam girders are a common type of structure used for strength and suitability. A T-beam consists of a flange and a web which resist compressive stress and resist shear forces respectively.Which increases the strength and suitability as mentioned above.

2. Background of Bridge

A. *Importance*

The 19th-century Aruvikkara Bridge, a narrow one-lane concrete structure,which face a lack of accommodation of sufficiend vehicle . With just 64 meters in length and under 5 meters in width, it faces traffic congestion in that area. Aruvikkara is increasing the importance as a tourist and pilgrimage destination has led to a massive change in vehicular movement .Bridge engineering enhances the performance of the structure. The existing bridge faces some issues like ageing, lack of high load bearing capacity. A new bridge is essential to use traffic congestion, enhance safety, and support economic growth and tourism in the area. It would give good connectivity, reduced travel time, and improved access for tourists and residents. Building a new bridge is a necessity for the future development and transportation efficiency of Aruvikkara and its surrounding regions.

B. *Objectives*

The objective of the project is to carry out the analysis and design using the software MIDAS. And mainly focused on the part deck slab. The deck slab is designed as manually and software for the comparison to ensure the accuracy of the result .A comparative study will be conducted to highlight the differences and similarities between manual and software based design approaches. Additionally, the complete bridge structure will be modeled in Revit to provide a detailed visual representation and aid in better understanding of the design.

3. Methodology

The proposed bridge near the existing Aruvikkara Bridge was planned due to excessive traffic congestion and the current bridge’s inability to support increasing vehicular loads. A new parallel bridge was selected to enhance traffic flow and manage heavy vehicles. The site was chosen based on favorable geographical and hydrological conditions for stability and durability. The study involved both community and traffic surveys to support planning and design. The community survey collected opinions on accessibility, safety, and environmental impact using structured questionnaires and diverse sampling. Feedback from residents, commuters, and stakeholders highlighted key needs and concerns. Simultaneously, a traffic survey recorded vehicle types and volumes using manual and automated methods across various times. Speed, flow, and origin-destination studies revealed road capacity and connectivity issues. Forecasting tools predicted future traffic growth to ensure long-term design efficiency. MIDAS software was used for modeling the bridge structure, applying loads, and conducting static and dynamic analyses. The software helped identify stress points, deflections, and performance under various load conditions. Design optimization and code compliance checks ensured a safe and cost-effective structure. Construction sequence analysis simulated the step-by-step erection process for stability during implementation. Manual design of the deck slab involved load calculations, moment and shear analysis, and reinforcement detailing per IRC codes. Cross-verification with MIDAS results ensured a structurally sound and serviceable final design ready for execution.

A. Community Survey

The community survey aimed to gather input from approximately 200 local residents, commuters, and business owners regarding the necessity and potential impact of a proposed new bridge near the Aruvikkara Bridge. The survey focused on understanding public opinion about current traffic conditions, safety concerns, accessibility issues, and overall transportation challenges. Respondents were asked about their travel frequency, primary routes used, and how a new bridge might improve their daily commute. The goal was to assess community support for the project and identify perceived benefits or concerns.

B. Traffic Survey

A traffic survey was conducted to assess vehicular movement and flow patterns in a 5-kilometer radius around the proposed bridge location. The survey aimed to evaluate traffic volume, peak-hour congestion, and the impact of festivals on road usage. The findings will assist in planning a bridge design that meets current and future transportation demands.

- Traffic composition:
    - Passenger vehicles: 40%
    - Light trucks: 20%
    - Heavy trucks: 15%
    - Buses: 25%
- Recommendations:
    - Design a 2-lane bridge in each direction
    - Add dedicated truck lanes
    - Include pedestrian and bicycle paths

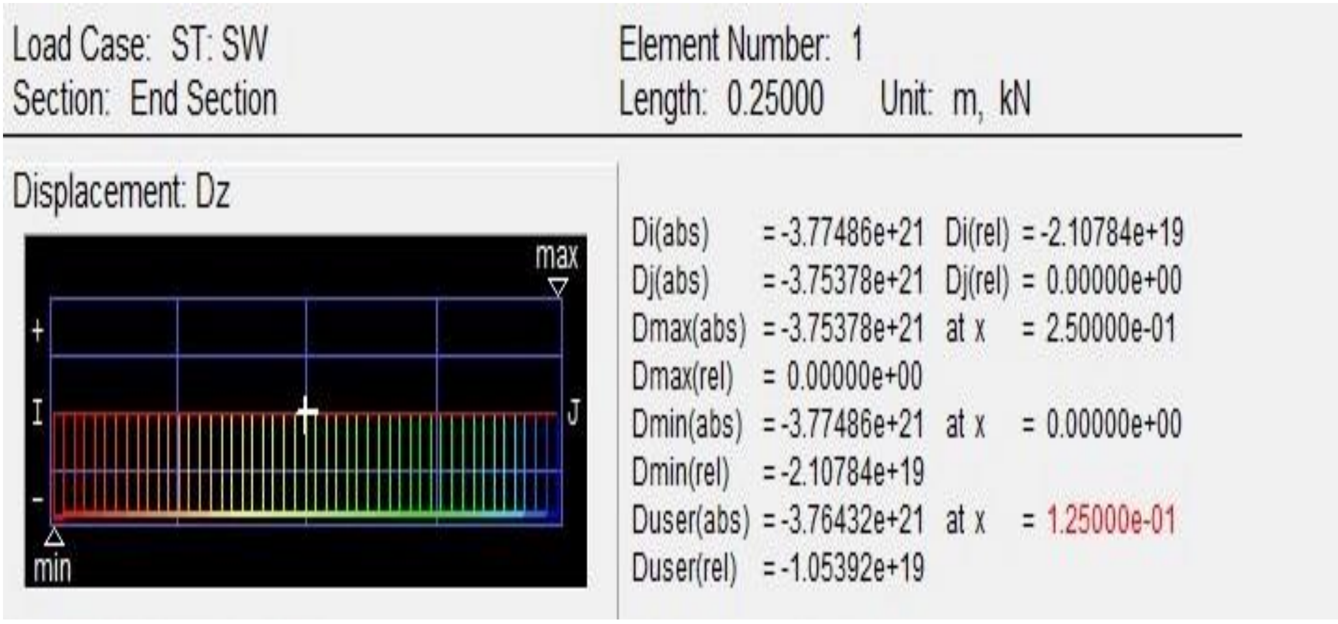
4. Results and Discussion

MIDAS is a leading engineering software suite widely used for the design and analysis of civil structures, especially bridges. It offers advanced finite element analysis (FEA) capabilities, allowing precise modeling of structural behavior under various load conditions. MIDAS Civil, a specialized module, is tailored for bridge design, helping engineers assess bending moments, shear forces, deflections, and stability. The software supports a wide range of bridges, which includes beam, arch etc. It enables different type of analysis which were static and dynamic. A major advantage is user friendy and give accuracy in analysis. Engineers can easily define materials, boundary conditions, and loading scenarios in 3D environments. MIDAS which help in non linear and time dependent software which help in doing the work as a safer on.

A. Design Parameters

Parameter	Value
Bridge Type	RCC T-Beam or PSC I-Girder Bridge
Total Length	64m
Width of Carriageway	7.5m (Two Lanes)
Total Width	8.4m (Including Crash Barrier)
Number of Spans	3
Number of Girders	3
Concrete Grade	M30
Steel Grade	Fe415
Column (Pier) Height	8.0m
Pier Diameter	2.3 m

B. Displacement Graph



This graph mainly indicate about under various load condition how the bridge deforms. Displacements are typically measured in vertical deflections, lateral movements, and rotations at specific points. For a 64-meter span bridge it is very much important ensure the load deformation . Excessive deflections may help you verify furthur modifications are needed for the structure.

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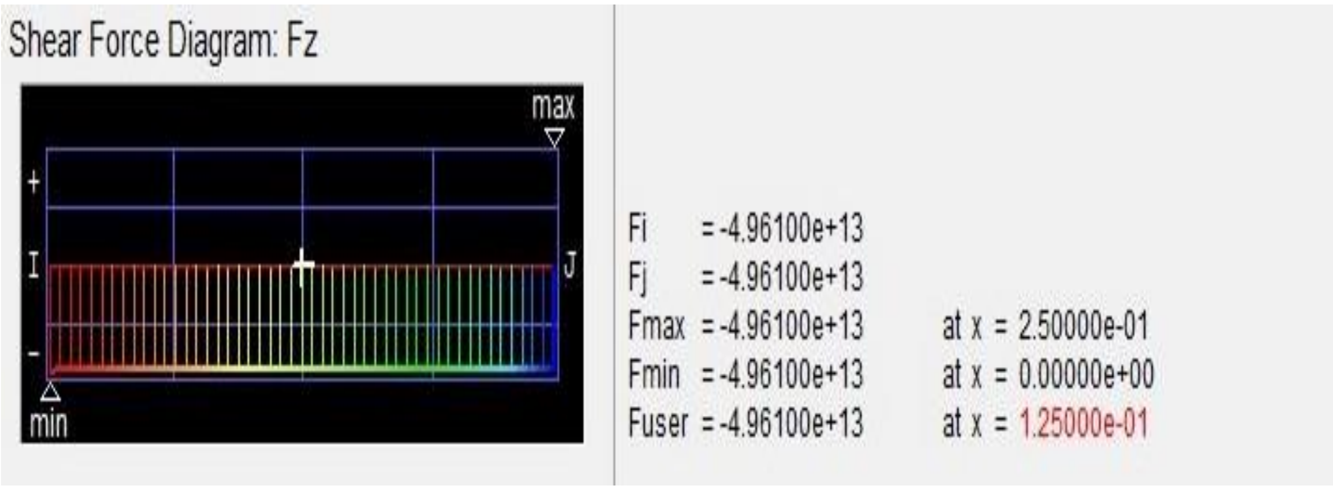
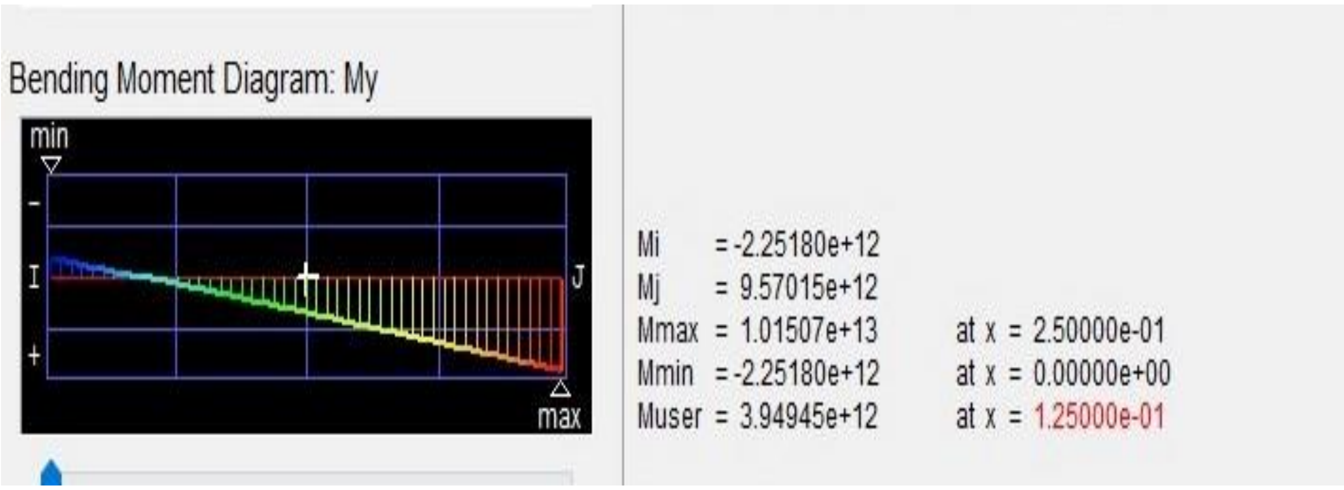
C. Shear Force Diagram



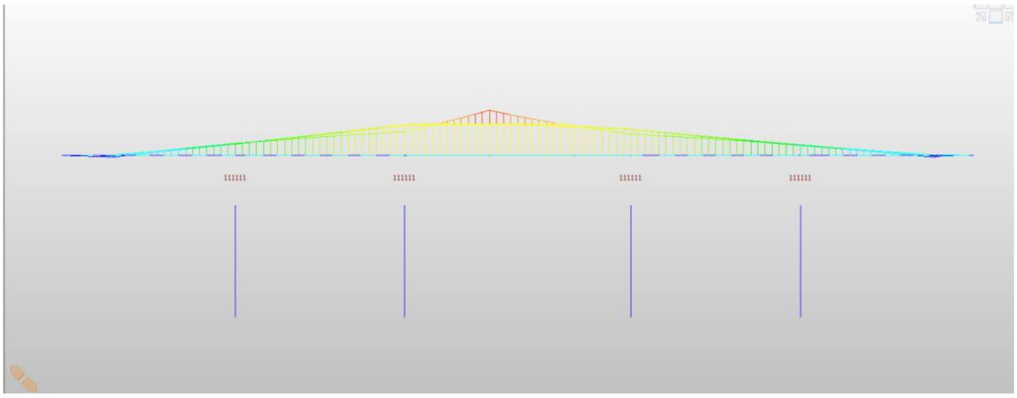
Shear force diagram indicate about the variation of shear forces throughout the length of the bridge. Shear forces arise from loads that cause one part of the structure to slide relative to the adjacent part of the structure. In the SFD, abrupt changes typically correspond to point loads, while distributed loads result in linear variations. Understanding the shear force distribution is essential beacause by the shear force determination designing of reinforcement ,in specially if any region experinces high shear force.

D. Bending Moment Diagram

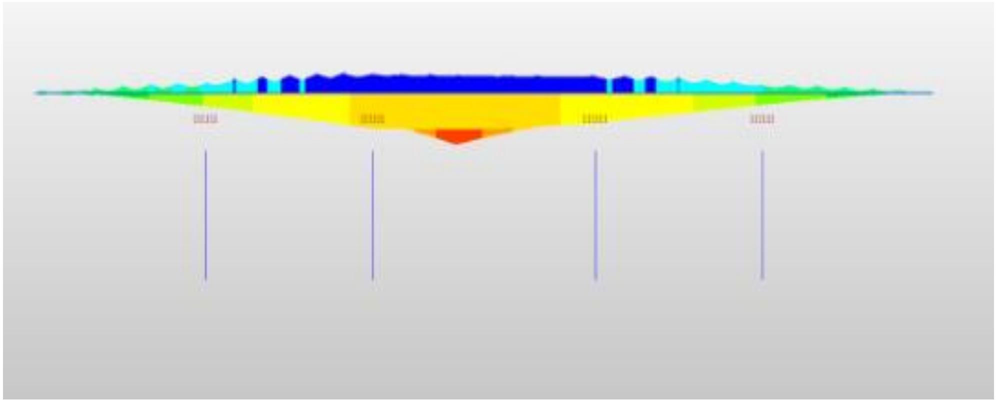


BMD gives the information regarding the variation of bending moment along the bridge .This diagram will help to know the portion faces critical or maximum bending moment thus replacement of material can be done with this.

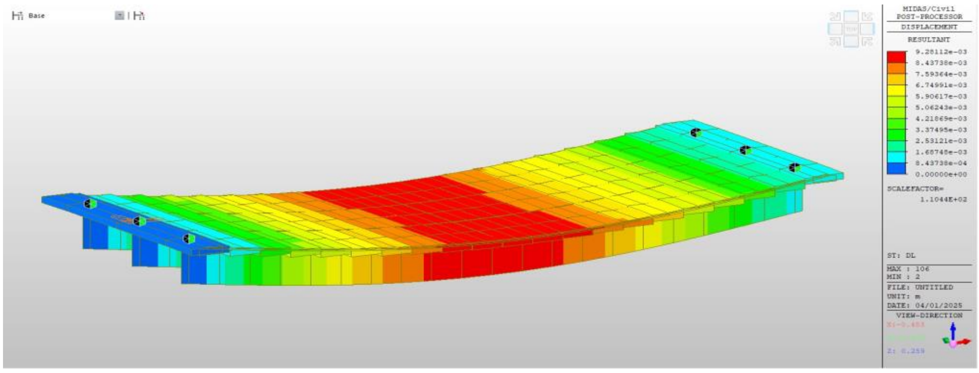
E. Bending Moment Distribution of a Multi-Span Bridge



The image is a structural analysis result from MIDAS Civil**,** displaying the bending moment distribution of a multi-span bridge. The colour variation mainly shous about the intensity of deflections.Red region experiences maximum and blue region experiences minimum.



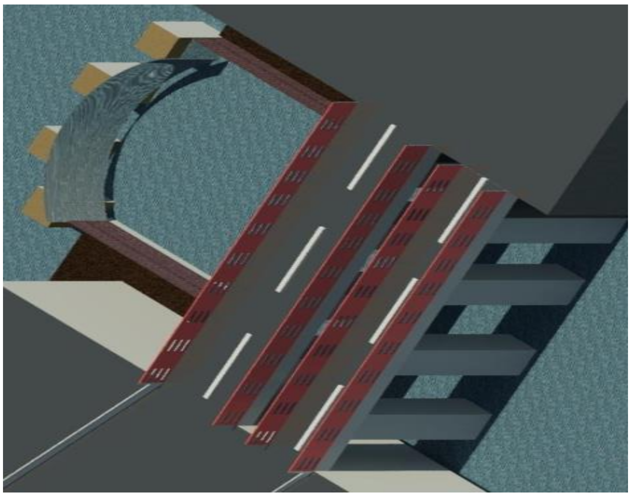
The image represents a structural stress distribution analysis of a bridge, likely depicting shear force or stress contours obtained from MIDAS software. The colour variation gives the info of intensity of bending moment. This analysis is important for ensuring high-stress zones, ensuring that reinforcement is provided in critical areas to increase the bridge's durability and structural integrity.



The image represents a structural displacement analysis of a curved bridge deck using MIDAS software. The colour gradient gives the displacement levels under dead load (DL)**,** with blue is the minimal displacement and red represents the maximum displacement at the central .The support locations are marked with black symbols, which verify the stability at the edges. The displacement values are scaled for better visualization, as indicated by the scale factor = 1.1044E+02**.** The bridge deck exhibits higher deformation in the middle. This analysis helps in verify the design by ensuring the structural integrity and serviceability of the bridge.

5. 3D MODELLING

Modeling a 64-meter span and 8.4-meterwide bridge in Revit involves precise geometry, parametric design, and detailed components to reflect real-world specifications. After setting the units and creating levels for the deck, girders, and foundation to ensure accurate placement. The bridge deck, modeled using the "Floor" tool, with appropriate materials assigned for visual accuracy. Girders, created with the "Beam" tool and a height of 1.8 meters, are aligned beneath the deck for structural support. T-beams, with a width of 0.3 meters, are added at regular intervals to increase the deck stability. Revit's parametric tools allow easy adjustment of T-beam sizes and placement for design flexibility. Piers are modeled using the "Column" tool with a 7-meter height and 2.5-meter diameter to transfer deck loads to the foundation as normal . Their accurate placement will ensures structural stability. With reinforcement detailing and accurate geometry, the Revit model ensures structural integrity and adaptability.



6. MANUAL RESULT

A. DESIGN PARAMETERS

Clear width of roadway =7m
Span centre to centre bearing =64m
Average thickness of wearing coat=8cm
Three girders are provided at centre-to-centre distance of 2.8m
Three graders are provided at centre-to-Centre distance of 2.8 m kerb of 0.8 m wide are provided cross section were provided and reboot 45 cm.
Cross girders us are provided at every 4.3 m to connect longitudinal beam.
The breadth of cross girders is 45 cm, thickness of the slab is assumed to be 22.5cm for interior panels.
Thickness of cantilever slab is assumed the 24 cm and junction a rib of 16 cm at junction with kerb.
The weight of railing is assumed us 70 kg/m.

B. REINFORCEMENT DETAILS

Effective depth = $\sqrt{(3403 * 100)/(12.13 * 100)}$ =16.74cm

Provide overall death of 25cm width effective depth of 17 cm.

Area for MB = (3403*100)/ (1400*0.87*17)

=16.43cm^2

Provide 12 mm diameter bars at 6 cm centres.

Effective depth of ML=17- 0.6-0.5=15.9cm

At= (1484.4*100)/ (1400*0.87*15.9)

=7.7 cm^2

Provide 10 mm diameter bars at 10cm centres

<u>Check</u>

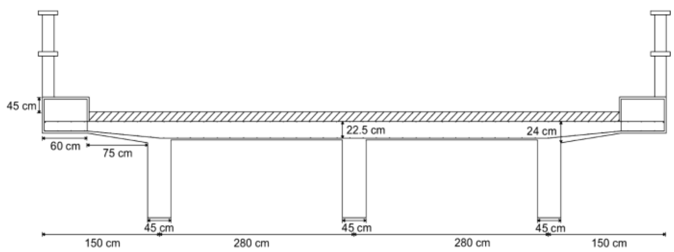
Check or shear $= \frac{7020}{100*0.87*17} = 5kg/m^2$

Hence safe

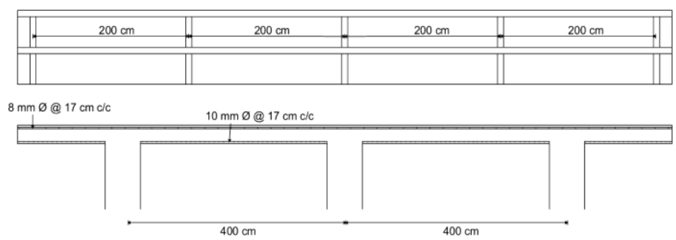
Two Third of the bars are taken straight

Bond stress $=\frac{7020}{0.87*17*\frac{2}{3}*100*3.77} = 18.8kg/m^2$

Hence safe



CROSS SECTION OF DECK SLAB



LONGITUDINAL SECTION OF DECK SLAB

7. Conclusion

Conducted a comprehensive analysis of the bridge design utilizing MIDAS software, which provided advanced modelling capabilities for evaluating structural integrity and performance under various load conditions. Additionally, we created a detailed 3D model of the bridge using Revit, allowing for precise visualization and integration of architectural elements and engineering specifications. This project aimed to design a bridge using MIDAS software**,** ensuring structural efficiency, safety, and compliance with engineering standards. The community and traffic surveys provided essential data on transportation needs, congestion levels, and public concerns, forming the basis for site selection and design considerations. Extensive traffic volume analysis and speed studies were conducted to forecast future traffic demands, ensuring the bridge can accommodate increasing vehicular loads.This combination of software applications facilitated an in-depth understanding of the design's feasibility and highlighted any potential areas for improvement.

Acknowledgment

We express our deep sense of gratitude to our guide Dr. Sunil J, Asst. Professor and Head of Civil Engineering Department, LMCST, Kuttichal, TVM for the valuable guidance, constant encouragement and creative suggestions offered during the course of this project, and also in preparing this report. We express our heartfelt thanks Dr .Beshiba Wilson, Principal, LMCST for their valuable support. We express our sincere thanks to the Management of LMCST, TVM for providing necessary facilities and their sincere co operation. Our sincere thanks are extended to all the teachers and lab assistants of the Department of Civil Engineering and to all our friends for their help and support.

Above all we are grateful to the Almighty God for his grace without which this project could not have been successfully accomplished.

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