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Prefabricated Bus Shelter - A Cost Effective solution

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Abstract – *Efficiency of a well-functioning public transport system plays a key role in the progress towards a socially viable and sustainable city. The allied Infrastructure services such as bus shelters, comfort stations, wheel chair accessibility ensures the effectiveness and utilization of public transport system. The current model of development that prevails in the country is not focusing much on the engineering aspect of these allied services. Even though the cost component involved in a single bus shelter may be small, the number of bus shelters required for every stretch of infrastructure development results in the utilization of a significant project cost. The Problems with current bus shelters are identified by conducting surveys and accordingly new configurations are attempted and analysed using STAAD. A feasible structure with stable and economic configuration was selected and compared with an existing structure to summarise that the proposed structure is more economical than the existing one.*

***Key Words*: STAAD, Survey, Takeoff, AutoCAD, Cost effectiveness**

1. INTRODUCTION

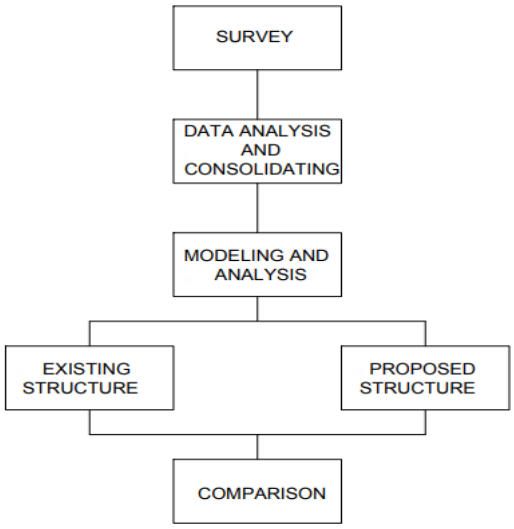
The challenge for any engineer today is to optimize and produce sustainable solutions in all arena of engineering. Public transport system development and its efficiency play a key role in the development of a city. An efficient public transport system can help a lot in reducing the traffic congestion caused due to preference of people to opt for private mode of transport. Bus shelter forms an inevitable component of this allied service system for public transport system. Even though a single bus shelter structure does not create a significant impact in cost for an infrastructure and public transport system development, the presence of large in number of this simple and small structure creates an impact in the total project cost. There is a strong need to upgrade the infrastructure and facilities of these spaces into hubs which meet the requirements of both customers and bus operators [2].

Above all, these structures are public property which is constructed by the government for public welfare with public money collected in terms of taxes and other government incomes. Thus the extra expenses spend to meet the requirements of these structures pose an unwanted burden on taxpayers. Hence a cost effective and stable bus shelter design with minimal material usage would save a large amount of public money.

This study is developed from the fundamental idea that stability along with functionality can be achieved at a lower cost by choosing a proper configuration and design. The project will comprehend the problem initially through a deep analysis of the existing over-designed bus shelters and thereafter comparing it with different proposed bus shelter configurations. The capability of the Analysis and design software package STAAD Pro has been utilized for analyzing different configuration for their structural efficiency. The project explores different functional parameters through survey and structural parameters through STAAD pro.

This project tries to stand out as a deviation from classic over-designed standbys to brave and bold new shelters by adopting a cost-effective way. Moreover, this is an initiative to conserve the hard earned public money that is paid to the Government in the form of tax.

2. METHODOLOGY



3. SURVEY

For the survey, a survey form (Fig 1) was prepared with basic queries about public usage of bus shelters including the essential details. Thus a preliminary survey was conducted to discern the basic requirements necessary for a public bus shelter [1]. The chosen study area is Thodupuzha-Muvattupuzha (SH 08). The current status of the existing bus shelter and the missing attributes were inferred through the survey conducted at different bus shelters throughout the study area.

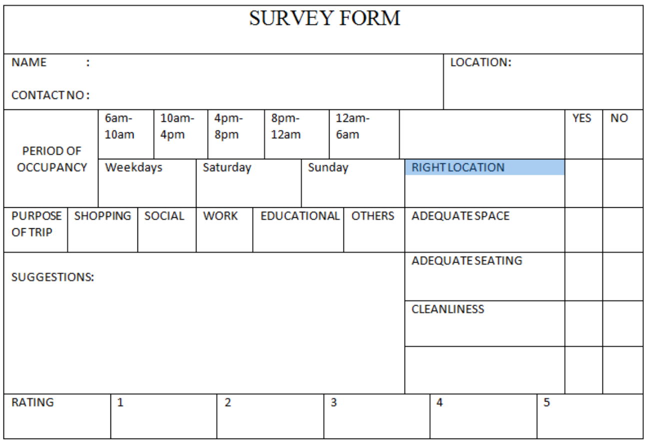

SURVEY FORM
NAME :
CONTACT NO :
LOCATION:
PERIOD OF OCCUPANCY: 6am-10am | 10am-4pm | 4pm-8pm | 8pm-12am | 12am-6am
Weekdays | Saturday | Sunday
PURPOSE OF TRIP: SHOPPING | SOCIAL | WORK | EDUCATIONAL | OTHERS
YES | NO
RIGHT LOCATION
ADEQUATE SPACE
ADEQUATE SEATING
CLEANLINESS
SUGGESTIONS:
RATING: 1 | 2 | 3 | 4 | 5

Figure 1 : Survey Form

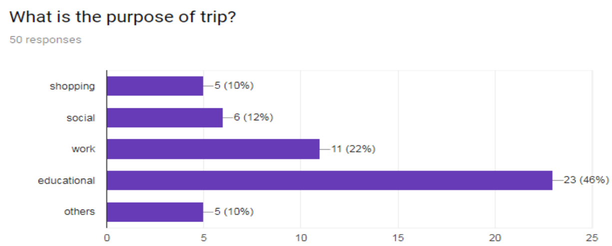
Survey includes the data collected from a total of 50 people at 3 major and 2 minor bus shelters along (SH 08).

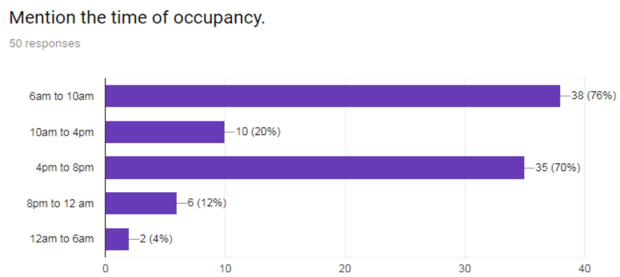
4. DATA ANALYSIS

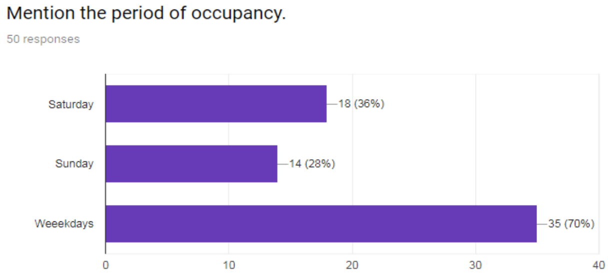
The basic dimensions are fixed on an average basis of the survey conducted and the details are further used for configuring the model.

It was deduced from the samples of the 50 people that the peak hours of bus shelter usage were in between 6 am to 10 am and 4 pm to 8 pm. During these intervals, the existing shelters are bulky and inconvenient for the people. The result of the survey rightly points out this fact that the space provided is inadequate. Furthermore, seating is only used by long distance travelers and elderly people, therefore seating requirements demand just secondary importance.

The data obtained from the survey was documented using Google form and converted the results into pie charts and bar charts (Fig 2).







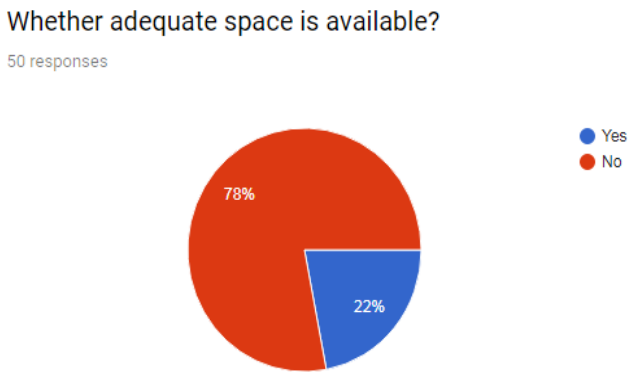


Figure 2-Survey Analysis

From the data, effective dimensions for a bus shelter was fixed and noted in Table 1.

Table 1: Proposed Dimensions

Proposed Dimensions
Length = 5m
Width = 2m
Height = 2.5m

Apart from the dimensions, the necessity of a bus shelter on a particular area, structural and hygienic requirements are also analysed from the survey and it lays the base stone for the design configuration of a stable bus shelter [3].

5. MODELING AND ANALYSIS

5.1 Parameters

Modeling and Analysis of the different configurations were done using STAAD. The wind loads together with the self - weight of the structure are the main loads that are acting on bus shelters. The self-weight of the different members of the structure is assigned as dead loads and in addition to this, the main load which causes the deflection of the structure is wind load. The load calculation for wind was done making use of the provisions in IS 875 part 3 [4]. The weight of a person leaning on the vertical supports of a bus shelter will be the additional live load acting on the bus shelter with isolated seating provisions. The effect of a person having a weight of 100 kg is considered as the leaning load in the modeling process. It acts as a point load on a height equals to the shoulder height of the person and it is assumed to be 1.6m. This load is applied at that level on all the vertical supports of the bus shelter.

All the proposed configurations were modeled and analysed for the safety parameters using the STAAD software package. After modeling the skeletal structure, sectional properties for legs, top plate, purling, beams etc. are assigned. Support condition assumed for the analysis is total fixity at the base.

5.1.2 Load Calculations

i. Leaning Load

Average weight of a person was assumed to be 100 kg
Therefore load = $100 \times 9.81 \times 10^{-3}$
= 0.981 kN
Height at which load acts is assumed to be 1.6m
Leaning angle = 10^0
Horizontal load = $0.981 \times \sin(10^0)$
=0.17 kN

ii. Wind load calculations [(4),(5)]

Wind load calculations is done in accordance with IS 875 Part 3
Basic Wind Speed at Cochin, V_b = 39 m/s
(IS 875 Part 3 Fig 1)
Design wind speed (V_z) = $V_b \times k_1 \times k_2 \times k_3$
Probability factor, k_1 = 1
(Table 1 IS 875 Part 3)

Terrain height and structure size factor, k_2 =1
(Table 2 IS 875 Part 3)
Topography factor, k_3 =1
(Clause 5.3.3 IS 875 Part3)

V_z = 39 x 1 x 1 x 1
=39m/s

Design wind pressure =$0.6\ v_z^2$
(Clause 5.4 IS 875Part 3)
=0.6×39^2
= 912.6 N/m²

5.2 Proposed Structure

Different type of design configurations which differs from form and structural elements were finalized and are detailed in Figure 4.

5.2.2 Structural configurations

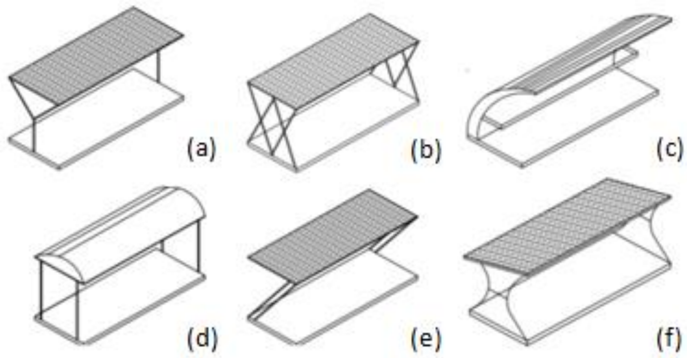
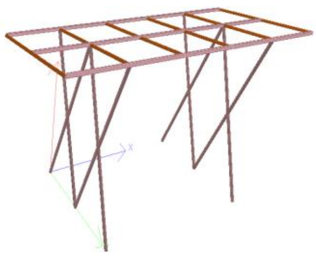


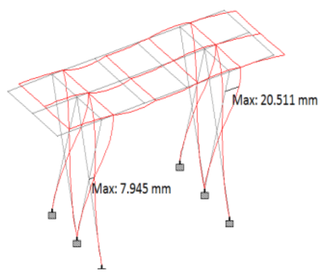
Fig 4-Structural Configurations

5.2.3 Analysis

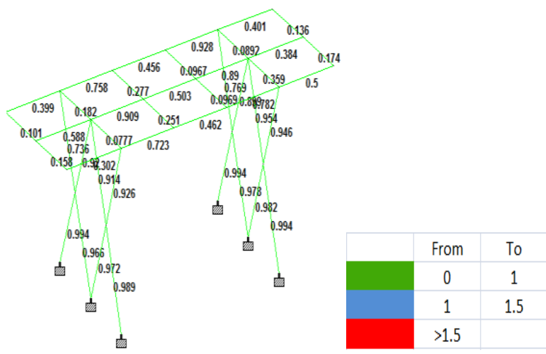
All the configurations were analysed in STAAD and it was found out that configuration (b) proved to be the most efficient structure considering the parameters such as deflection, material utilisation, space utilization and functionality. The relevant analysis results of the finalised configuration are depicted in fig 5



(a) 3D rendered view



(b) Deflection Diagram



(c) Utility Factor

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STEEL TAKE-OFF
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  PROFILE                 LENGTH(METE)      WEIGHT(KN  )

ST  PIP483H                  21.54            0.922
ST  TUB40403.6               15.06            0.568
ST  ISA40X40X5               12.06            0.350
                                        ----------------
                         TOTAL =              1.840
```

(d) Take off

Fig 5-Analysis results

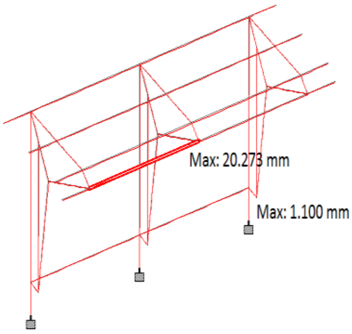
5.3 Existing Structure

One of the existing Bus shelter in Thodupuzha-Pala route is considered for detailed analysis and comparison with the proposed structure.

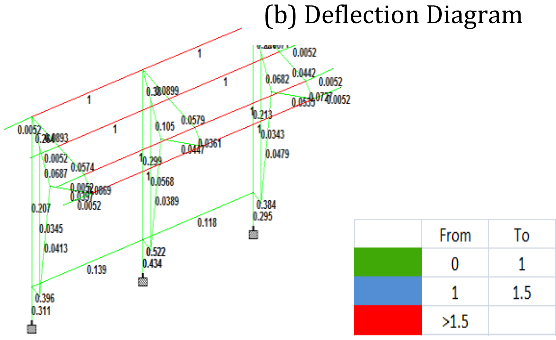
5.3.1 Analysis

The Side view and perspective views of existing structure is shown along with the relevant analysis results are depicted in fig 6

(a) Actual Diagram



(b) Deflection Diagram



(c) Utility Factor

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STEEL TAKE-OFF
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  PROFILE                 LENGTH(METE)      WEIGHT(KN  )

ST  TUB30302.6               22.00            0.453
ST  PIP483L                  25.54            0.812
ST  PIP1524M                  8.22            1.408
ST  PIP1016H                  4.40            0.493
                                        ----------------
                         TOTAL =              3.167
```

(d) Take off

Fig 6-Analysis results

6. COMPARISON

After the analysis process, both the proposed structure and existing structure were compared for the most relevant parameters to judge the safety and sustainability and are tabulated in table no. 2

Table -2: Comparison Results

Parameters	Existing	Proposed
Takeoff (kN)	3.167	1.87
Length (m)	5.54	5
Width (m)	2	2
Height (m)	2.74	2.6
Maximum Deflection (mm)	20.27	20.5
Least Utilization factor	0.005	0.027

Having the same deflection under similar loading condition, material quantity of existing structure is found to be 1.69 times higher than that of the proposed structure. Existing structure displays distress in some of the members to unacceptable levels when subjected to the load. The distress indication has been compared using the utility ratio diagrams(Figure 6) and values as in table 2.

7. CONCLUSION

This study emphasize on the need of proper planning and design of allied service of public transport system – bus shelter. The savings in the material and safety of the structure against the expected design loads specified by the Indian standard codes can be achieved only by conducting a detailed study of the various structural and functional parameters. Here the functional parameters are taken care of through the data analysis of the user survey input. This study reveals the amount of material used in a common bus shelter configuration is almost double than a properly engineered configuration. Even after using double the material the structure fails to meet the safety criteria when subjected to wind loads as per IS 875 part 3. The existing structure do have a functional advantage of obstruction free space inside the shelter compared to the proposed structure yet double material utilization ceases its efficiency in terms of economy and sustainability.

8. REFERENCES

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