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SIMULATION OF JOINT RIGIDITY IN BUS BODY STRUCTURE

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بسم الله الرحمن الرحيم

TO MY PARENTS IN GRATITUDE

TO MY FAMILY IN LOVE

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SUMMARY

The present work is an investigation carried out to determine the rigidity of the super structure joints of NASR 811 Bus body which is locally assembled. This bus is the latest model used in Cairo transport authority as well as Alexanderia transport authority.

A computer program based on the finite element technique was developed to compute the deformations of the loaded frame members.

The computed results of the T-joint frame were compared with the exact solution, and it was found to be in fair agreement. i.e. the program is valid for the frame analysis.

T-jointed box sections were made with brackets of the different dimensions and shapes usualy found in the bus superstructure, these T-joints were analysed theoretically.

The study concluded that the bracket dimensions can be taken into consideration in the theoretical analysis by introducing an equivalent length of the member. Design charts were obtained to estimate the equivalent lengths of a closed frame in case of using brackets at the joints.

A test rig was constructed to test four T-joints commonly used in constructing NASR 811 bus body superstructure. The experimental results were compared with the coressponding theoretical ones,a discrepancy of the order of 12% was found. These

inagreements were related to slip and friction at the supports on the test rig.

The recommendations from this work are :-

1- When brackets are used in the construction of the body frame , equivelant length must be used in the finite element analysis.

2- Local rigidity in the vicinity of the body openings such as windows should be increased by using brackets.

CHAPTER 1

INTRODUCTION AND REVIEW OF PREVIOUS WORK

Vehicle structures have developed through history. Wheeled vehicles in the earliest forms of both road and rail vehicles inherited their characteristics from drawn carriages. These had been developed by trial and error and basically consisted of a wooden frame with the essencial load carrying memebers in the floor. This type of construction is still almost universal in commercial vehicles where considerable and increasing effort is being expended on the design of the chassis frames by adopting an accepted practice and re-thinking the whole problem.

The development of an all metal construction from the separate chassis to the integral structure was rather an integration of the two components , the chassis frame and the body. Strength is realized by integration , while noise insulation is achieved by separation. It was realized that the two sides of the metal structure of an integral vehicle carried a large portion of the load. Attempts were made to analyse it as a truss in bending [1*]. The success of the digital computer in analysing complex structures partially initiated this approach.

G.H.Tidbury [2] presented a historical review on methods adopted in vehicle design. He found that the digital computer had made the analysis of such complex structures possible either adopting vertual displacements or direct force analysis

[*] Referances are given at the end.

at joints. He emphasised the use of vertual displacement method.

John Fenton [3] applied Argyris method for idealized Van body shell. This method depends on subdividing the structure into separate " stress " systems. Applying unit loads to the stress systems one can built-up the matrices to evaluate the member forces which can be solved using a computer.

Dean-Averns [4] stated that the stressing cases considered for a typical public service vehicle frame are:

1- Static loading for chassis only.

2- Static loading for body and ,

3- Braking reactions (load transfer due to maximum braking)

He emphasised that these static calculations can only be relevant as comparative stressing cases. He stated that , if the stress level is kept to 9300(N/cm^2) , the frame will be strong enough for a public service vehicle. Elementary calculations of this type were still the only ones carried out by many bus body design organizations , since the continual testing of similar chassis frames allows the maximum stress level to be accurately adjusted to suit the type of frame used.

Tien-Tzai Hawang [5] thinks , according to theoretical and practical analysis of the failure of the Chinese bus bodies , that not only the bus body posts should satisfy the design criteria , but the bus frame also must be warranted sufficient torsional rigidity. He made his experiments and analysis on bus of type called " semi-carrying " bus body structure. Buses of this type consists of the body superimposed on a load-carrying frame. All members of the body framework are jointed together by welding. Door and body posts are welded to outriggers on the frame. Since the body framework is mounted and connected rigidly on the frame , the body will directly suffer the shocks or impacts imparted by rugged roads. Loading cases were taken as follows , static torsional testing , turning sharp corner , emergency braking , and passing over a section of cement road at speed of 10 and 20 (km/h) , along which a great many wood pillows (3 and 10 cm in height respectively) lay across the road. Test results showed that , brittle coating cracks concentrated at the upper corners of the door posts and the upper and lower corners of the side window posts. Directions of the cracks are approximately perpendicular to the axis of the posts. Also in static torsional test at full load , the maximum stresses up to yield strength occured on the upper corner of the door posts and the lower corner of the side window posts. Test results showed that , the measured maximum stress point basically agree with the failure points in service. Practice showed that , while vehicle passes over bumpy road at a lower speed , the vehicle body suffers from most strenuous torsion. In case of torsion , time history of dynamic load is very slowly. Of course , inertia load is very small , therefore , the torsion character of body may be looked on as static approximately. Finally the test results also showed that , both the weak region of the bus body framework , which was measured from static torsion and dynamic test , gave a good agreement , that is , the maximum stress points in static load case are the maximum stress points in dynamic case. Therefore , the test results of static torsion form a true estimation of the framework strength. Tien-Tzai stated that this type of semi-carrying bus body structure is an adaptable technique which have been developed under certain conditions in Chinese automotive industry. The said structure has the advantage of lower technical requirements and cheap cost of production.

Frank Monasa and Timothy Chipman [6] explained how to evaluate the structure load carrying capacity of the passenger compartment of small buses. An analytical technique , based on the finite element method , has been described to perform an elastic-plastic structural analysis of the passenger compartment of small buses under quasi-static loads simulating severe or high-speed frontal and side impact loading conditions. The analytical procedure and the computer program provide a technique for , tracing the load-displacement history of a space frame structure , determining the collapse or the ultimate load , predicting the collapse mode. In this study the passenger compartment posts and pillars connections to the chassis ' cross-members or the outriggers were assumed to be rigid , and the other joints were assumed to be rigid or pinned depending on the type and detail of connections.

David J. Schwartz [7] suggested two techniques to analyse stress raisers in solid structures. The first technique is the linear constraint (LC) method and the second one is the specified boundary displacement (SBD) method. In short the LC and SBD methods use compatible , isoparametric shape functions for solid elements to express the displacement field from a coarse stuctural mesh which supplies the boundary displacements to a refined mesh at a stress raiser. Numerical tests of the two methods demonstrated good to excellent accuracy , even with abrupt changes in fine-to-coarse mesh density, for two common stress raisers. David stated that the LC and SBD methods utilize only the standard features of commercial finite element programs making them practical for both large and small scale structural analysis activities.

Dusan Kecman [8] designed a program named " WEST "(Weight Efficient Safety Tubes) as a simple aid to the designer and analyst when considering rectangular or square section tubes with impact safety in mind and to overcome the problem of selecting components in the light of some or all of the following criteria : Weight efficiency for selected material , Cost efficiency , Design limitations due to component availability, styling , production as well as compatibility with other body components. He stated that the capability of a design to meet specified safety criteria depends mainly on : overall collapse mode of the structure , stiffness , strength and energy absobing capability of the deforming components , and strength , remaining after deformation. Tests (cantilever bending tests) were carried on 27 different sections of tubes statically as a comparative tests. He plotted curves as relations between moments, angles of rotations , and deflections. Also there are some relations between section dimensions. Stress-strain curves were plotted for the different tubes. It was established that the presence of shear force did not have a noticeable effect on the hinge collapse behaviour (in short beams this may not apply). He found that higher strain rates reduce material ductility and the possibility of material separation has to be considered.

Ken Kiriaka [15] presented a practical method for investigation of the behaviour of a space framed structure subjected to a quasi-static barrier load. He described an analytical method based on the incremental finite element techniques with the contact effect taken into consideration using a computer program. Investigation has been made on whether this method is applicable to evaluation of crush characteristics of an automobile body structure. Any difference in idealization from the actual body structure to the space frames makes it difficult to calculate exact deformations. This method is an effective mean of obtaining the collapse load of a body structure subjected to a barrier load during early design stages.

Te-Chang and Kwork-Hung [16] studied the nonlinear behaviour of non-integral infilled frames (in which the infill and the frame are not bonded together) experimentally and analytically. They used the finite element method in the theoretical study, and the nonlinearities of the material and the structural interface were taken into account. From the study it is shown that the stress redistributions towards collapse are significant , and that the strength of non-integral infilled frames is very much dependent on the bending strength of the frame. They studied the effects of initial lack of fit and friction at the interface. Furthermore they proposed an imperical formulae for estimating the equivalent strut width.