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Review of Design & Development of Upright & Base for Shelving System

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Abstract- **Shelving racks are used for the display & storage of Books, paper products, FMCG goods, electronic goods, canned goods, hardware, any boxed-products etc. CAEM is shelving Engineering for the Retail Sector having more than fifty years of experience in the manufacturing of modular metal shelving systems for the shop fitting industry with the headquarters in Italy. The main structural members of steel storage racks are uprights & Bases. CAEM India imports upright & bases from CAEM Italy for shelving rack system. This project aims at developing the alternatives substitute for the structure of the system, to avoid the probable /current failures & cost effective solution. In this conceptual paper, a model of upright & bases is presented.**

Keywords- **Base, CAEM, Shelving, Upright.**

I. INTRODUCTION

CAEM is Shelving Engineering for the Retail Sector having more than fifty years of experience in the manufacturing of modular metal shelving systems, CAEM offers today the widest and most complete and quality oriented shelving system and display solutions for the shop fitting industry. These units are designed to have modularity according to the need of customer, also designed to have interchange-ability so that the shelves can be erected as per site requirements. The headquarters is in Italy and the company's direct presence is guaranteed in the UK, in Australia and in India.

CAEM offers display solutions for all retailers, namely: Hyper Markets, Supermarkets, Departmental Stores, Fashion Stores, Consumer Durables, IT and Home Entertainment stores, Specialty stores and Convenience Stores. CAEM work to the highest standards to maintain a modern approach to modular shop fitting. The high quality of products along with the continuous development of new and innovative design solutions gives a strong competitive advantage [9].

CAEM India imports upright & bases from CAEM Italy for shelving rack system. As the items are imported they are very costly & also they are difficult to manufacture them in India because of their unique design, number of bends and the special certified high strength steel.

Again sometimes it is difficult to predict their requirement which increases the lead time for the project due to the shortage of upright & bases. Over prediction also leads to increase in cost of inventories. This project aims at developing the alternatives substitute for the structure of the system, to avoid the probable /current failures & cost effective solution.

II. REVIEW OF PAPERS

The various points like the dimension, codes and loads that should be specified in order to have a storage rack or shelving system that is economical and safe. The important dimensions to specify are length and width of shelf, and the height between shelves. From the size of the product and pallet, one can determine the depth of the upright or truss. The overhang is required when the shelf beams are not covered with say a sheet of particleboard and the pallet and load could fall between the beams. The upright depth of back to back of column would then be 48 inches minus a total overhang of 4 inches or 44 inches back-to-back of column or rack post. If back-to-back rows are being considered, then one must consider the clearance between loads at the back in order to position the uprights for back-to back rows are length and width of shelf, and the height between shelves. [1]

The product load or shelf load should be always specified. The shelf load will then be used by the shelving supplier to determine the reinforcement, if reinforcing is necessary. Most

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manufacturers have members such as bars and angles that reinforce the front, back, and side edges; as well as hat shaped sections that reinforce the centre of the shelf by spanning the length the shelf at the centre of the shelf.

Failure analysis is an engineering approach to determining how and why equipment or a component has failed. Some general causes for failure are structural loading, wear, corrosion, and latent defects. The goal of a failure analysis is to understand the root cause of the failure so as to prevent similar failures in the future.

In addition to verifying the failure mode it is important to determine the factors that explain the "how and why" of the failure event. Identifying the root cause of the failure event allows us to explain the "how and why" of failure.

Common causes of failure include:

- Misuse or Abuse
- Assembly errors
- Manufacturing defects
- Improper maintenance
- Fastener failure
- Design errors
- Improper material
- Improper heat treatments
- Unforeseen operating conditions
- Inadequate quality assurance
- Inadequate environmental protection/control
- Casting discontinuities [2].

The main structural members of steel storage rack frames are uprights and pallet beams. While pallet beams brace uprights and provide stiffness against down-aisle buckling through semi-rigid connections to uprights, the most critical members of a rack structure are the uprights, which are usually made from cold-formed open sections. They are the members most affected by instability, including local buckling, distortional buckling and member flexural and flexural-torsional buckling. Steel storage racks may be braced or unbraced in the down-aisle direction. When braced, the spine bracing is accompanied with plan bracing, to also provide down-aisle bracing of the front row of uprights. The down-aisle buckling capacity is affected by the stiffness of the semi rigid connectors (joints) between uprights and pallet beams, and the semi-rigid stiffness of the base plate connection between the upright and floor, of which the latter is dependent on the axial force in the upright. The stiffness of these joints can be determined according to the testing provisions of the draft Australian standard, which are based on those of the European Standard for steel storage racks EN15512 (2009)[3].

Performance of pallet racking systems depends upon the efficiency of beam-end connectors, which provide, together with column bases, sources of stiffness for down-aisle stability. Knowledge of the actual joint behavior under static and seismic loading is of fundamental importance for a suitable definition of simplified moment rotation joint relationships to use into design of semi-continuous frames [4]. Rack systems are very similar to the framed steelworks traditionally used for civil and commercial buildings, but great differences in member geometry and in connection systems. In rack system, the beams are generally boxed cross-section, and columns are open thin walled perforated section to accept the tabs of beam end-connectors [5]. Various racking manufacturers and retail owners were consulted to establish the pre-event condition and loading of the systems and the response of the systems in both 'public accessible' and 'industrial' situations [6]. The main characteristic of the column, however, is the existence of perforations along its height that allows fitting the connections of braces and other structural elements [7].

Companies' success depends mainly on their products price, quality, competitive positioning, differentiation, etc. In the past companies tended to focus on individual products, but today there is greater attention to product families. While the product family approach facilitates targeting broader market opportunities, it also adds complications as the approach is usually based on a platform shared by several products that are differentiated with specific components targeting specific market niches. Hence, if the platform has a problem, then this problem contaminates every single product that has been derived from it [8].

III. PRESENT DESIGN

Initially a design is made as a solution for the TN9 Italian upright & base. In this design 80x40x2mm thick rectangular pipe section is used for both upright & base as shown in fig.1. The pipe is cut as per the required dimension for both of the upright & base. The slotting is done on the upright pipe in such a way that, the pitches of the slots made are compatible with the other assembly items such as backplanes, brackets, and loading bar etc. A flange of size 75x75x3mm thick is welded on the top of the base as shown in the fig.1. The upright is inserted vertically into the flange. The outer dimensions of the flange are smaller than that of the inner dimension of the upright. Once the upright is inserted into the flange the assembly is tightened by the use of fasteners.

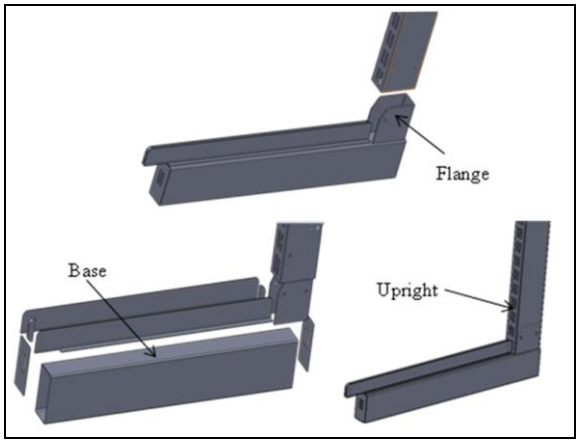

Fig.1 Present Design

Fig.2 Failure of upright & base

The system is put under a specific loading condition for certain duration of time. A test is carried out on it after which it is found that the suggested design for upright & base is failed as shown in fig-2 on the specific loading condition. Initial reasons of failures for the suggested design is observed are as follows:

- The load acting on the upright is not going directly towards earth.
- The load acting on the upright is carried by the base.
- The height of base is used as 8cm instead of 16cm for more than 200cm ht. of upright.
- The thick ness of pipe section for base & upright is used as 2mm instead of 2.5 to 3mm which normally used in other shelving system.

IV. CONCEPTUAL DESIGN

After identifying the mode of failure in the present design, a few conceptual designs options are made for the same. Ides behind this design is to overcome the previous reasons of failures & suggest an appropriate suitable design for the same.

A. Option-1

In option-1 the design is similar to the present design as described above, only the difference is that the flange is welded to the front of the upright instead of welding it to the top of the base as shown in fig-3.

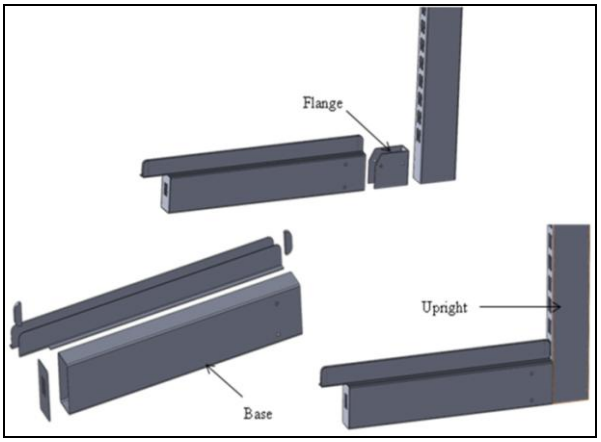

Fig.3 Design Option-1

Thus the base is inserted into the flange which is welded on the upright. The design has an advantage that the load on the upright is not acting on the base as compare to the present design. The load is directly going to the earth and helps in balancing the overall load acting on the system. The idea is same that of the TN9 system which has similar type of arrangement which normally used in Italian shelving.

Once the base is inserted into the flange the assembly is tightened by the use of fasteners. The rest of the assembly components are made similar to that of present design.

B. *Option-2*

In option-2 the concept is same i.e. the upright is of full length i.e. up to the ground and the base is inserted to the slot made on the upright.

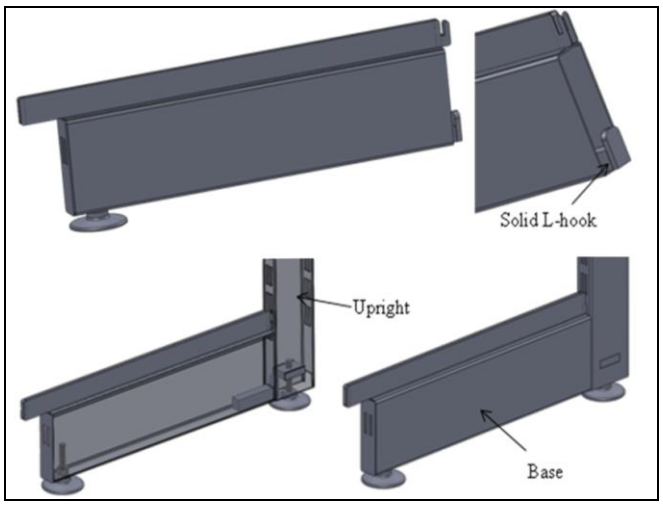

Fig.4 Design Option-2

In this, a solid L-hook is welded on the back side bottom of the base pipe as shown in figure 4. The slots are made on the upright pipe in which the L-hook & top plate brackets are hook tightly. The system is completely modular and there is no need of fasteners to fix the upright base assembly.

C. *Option-3*

In option-3 the base & upright are directly welded to each other. Welding can be done by selecting any one option from above. The rest of the assembly components are made similar to that of the present design. The welded option provides rigidity to the system & avoids assembly problems because of inaccuracy in dimensions of the assembly components.

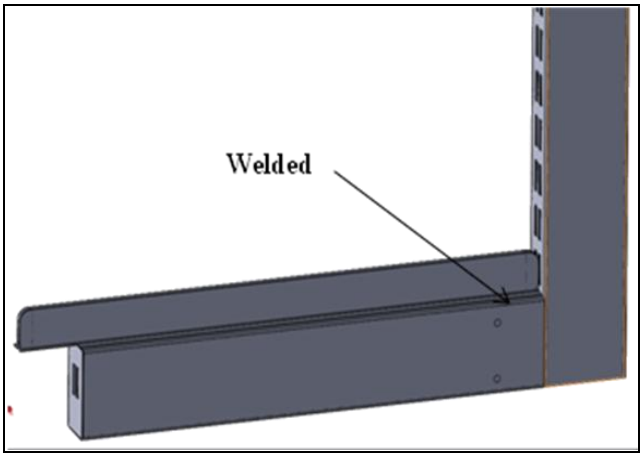

Fig.5 Design Option-3

V. SELECTION OF DESIGN

Option-2 is the best suited design for the project because:

1) The load acting on base & upright is carried by themselves separately.
2) The load acting on the upright is going directly towards earth.
3) In the welded option one has to maintain different combinations of uprights & basses. There are different heights of uprights available i.e. 88cm, 112cm, 120cm, 134cm etc around 25nos. of sizes. & different depths of bases available i.e. 20cm, 30cm up to 80cm. around 8nos. of sizes.
4) So if the welding option is used their will be 'n' number of combinations of upright & bases. In this case it is very difficult to maintain the separate stock of upright & bases combinations in warehouse which will directly leads to fatigue & increase is in inventory cost.
5) In case of option one it is difficult to weld the flange perpendicular on the top of the upright. If the welding is not done properly the misalignment will be their & will be difficult for the assembly.
6) Completely modular system.
7) No need of fasteners.
8) Simple assembly & saves time for the installation.

VI. CONCLUSION

In this paper, the proposed design for the Upright, Base & their assembly is being developed. Design option-2 is the best suited design for the system & is being finalized for the analysis & experimentation work.

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