Merits of rack supported, automated and safe steel warehouse

by
Rajagopalan Jagannathan
Juha Suksi
Pesmel Oy
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Dear Reader,

Storing coils or sheet packs or heavy plates or long products in a compact area vertically, utilizing the height helps on easy tracking and shipping as well as saving space and costly buildings. Rack supported warehouse with ASRS (Automatic storage and retrieval system) is an innovative method of best utilizing the storage racks for supporting the side cladding and roof sheets of the ASRS building thus avoiding separate building for the warehouse and saving approximately 3 times the area and 2/3rd of the cost of the warehouse building.

Today, with the digital controlled warehouse management system (WMS) and rack supported ASRS building, steel logistics and warehousing have become a cake walk with the assurance of total safety, total quality and prompt dispatch to enhance profitability and CRM.

In this paper an attempt has been made to list out the concept, objectives, functions, methodology and merits of “Rack Supported Steel Warehouse”.

Key words: ASRS (Automatic storage and retrieval system), WMS (Warehouse management system) and CRM (Customer retention management)

Authors:

Jagannathan Rajagopalan
Managing Director,
Pesmel NA and South Asia
Tel. +1 972 977 0518
jagannathan.rajagopalan@pesmel.com

Juha Suksi
Sales Director
Pesmel Oy
Tel. +358 207 009 624
juha.suksi@pesmel.com
Introduction

A rack supported warehouse is where the racking meant for holding the material is also used to support the walls and roof of the warehouse. It makes sense to utilize the racking (with storage of steel coils/plates/sheet packs/long products), which has the high modulus of rigidity and bulk strength for supporting the roof and side claddings with appropriate purlins. Considering that the cost of land, materials and labour continue to rise, the rack supported building concept becomes a more economical warehousing solution to high bay storage of above 25 meters with automatic warehouse management system (WMS).

These warehouses consist of the racking system that provides the basic structural support for the building's roof and walls. Maximum density storage solution possible for every type of pallet rack reduces the construction costs, lead times and building footprint. Rack supported building concept is obviously the optimum solution to store at a large heights making the most of the available surface.

With the warehouse management system and total automation, total safety is assured for the operators as there is no human interference required within the fenced warehouse functions.

There are two ways to build the racking:

1. **Rack supported Building**

Walls and roof are mounted directly to the rack as clad rack system. Clad rack construction means that the system is roof and wall bearing. This has as a consequence that the racking has to take up, besides bay load the crane loads and seismic forces, as well external loads like for example forces from wind snow, wall and roof cladding. Please refer to figures 1 and 2.
2. Free standing rack construction

Free standing rack construction means that the system has to take up bay load, crane loads and seismic forces, but no external loads like wind, snow, wall and roof cladding. This has the benefit that the racking construction can be built approximately 10% lighter, but needs another separate building which could cost 60% more with many operating constraints. Figure 3.
Rack Support Concept

The specialty of this construction is that it does not require conventional structural columns to support the walls and roof. They are fixed directly on to the racking structure to complete the building. There are no interference with building columns and also huge savings can be realized in construction time and cost. One significant financial advantage is the shorter depreciation which is equal to machinery.

The components of rack supported buildings are namely:

a) Racks - simple or conventional/double deep or multi deep (Figure 4) or single cantilever types.

b) Roof truss supported on the racks

c) Purlins – supported on the roof truss for the roof sheeting and side racks for the side wall cladding.

d) Roof sheeting and Side Cladding Sheets. These sheeting could be galvanized or galvalume and colour coated. Please refer to figures 5 to 8 and table 2 below.

e) Civil work. – anchor bolt foundation pits, floor rafts and slabs, draft walls, fencings, gates and doors

f) Lighting

g) Ventilation

h) Water drain system

i) Safety systems: safety interlocks and automatic monitoring system for any intrusions and manual interference to insure total safety
### Construction sequence and configuration features comparison

<table>
<thead>
<tr>
<th></th>
<th>Normal warehouse</th>
<th>Rack supported Warehouse (RSW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy foundation work</td>
<td>Construction can start with raft and slab and light unit foundation work per ton stored</td>
<td></td>
</tr>
<tr>
<td>Large redundant columns</td>
<td>Uniform racks</td>
<td>Supported on racks, no truss required</td>
</tr>
<tr>
<td>Roofing and side cladding, supported on columns and trusses</td>
<td>Supported on racks, no truss required</td>
<td></td>
</tr>
<tr>
<td>Gable end wind girders</td>
<td>Not required</td>
<td></td>
</tr>
<tr>
<td>After this flooring and then racking work starts</td>
<td>RSW is complete in the previous step</td>
<td></td>
</tr>
<tr>
<td>Less height for storage</td>
<td>More height for storage</td>
<td></td>
</tr>
<tr>
<td>Static building</td>
<td>Dynamic building with WMS</td>
<td></td>
</tr>
<tr>
<td>Less utilization space</td>
<td>Best utilization of space and volume</td>
<td></td>
</tr>
<tr>
<td>Low storage capacity per unit</td>
<td>High storage capacity per unit area</td>
<td></td>
</tr>
<tr>
<td>Low efficiency and throughput</td>
<td>High operating efficiency and throughput</td>
<td></td>
</tr>
<tr>
<td>Costly considering low efficiency and high resource requirement and stringent monitoring requirement</td>
<td>Most cost effective with lowest life cycle cost</td>
<td></td>
</tr>
<tr>
<td>Semiautomatic Yard Management System (YMS)</td>
<td>Totally automatic Warehouse Management System (WMS)</td>
<td></td>
</tr>
<tr>
<td>Less safe due to human interface</td>
<td>Total safety with no people physical interface</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Construction sequence and configuration features comparison
Typical construction sequence

Construction of rack supported building begins with pouring of the slab and anchors and erection of the rack. Since there is ample space due to the lack of enclosures, the multiple frames are assembled on the ground and then lifted and held to stand up on the slab and bolted up. This type of construction could assure accurate alignment, thus minimizing the time required to complete the plumbing of the racks during erection.

Rack supported ASRS with total automation and total safety

In automatic ASRS there are no people needed in the warehouse during operation which makes it totally safe. There are tracking software to track bar code or RFID tags, diagnostic software, safety software and warehouse management software all of which insure total automation with assured safety to the supervisor who would be outside the warehouse area or in the control room generally. The total ASRS is within the fence and the gates are with interlocks for safety.

When supervisor or maintenance technician need to enter the storage area for inspection, the total system has an interlock at the gate and the operation of the stacker crane stops with zero risk. Further the stacker cranes are with inbuilt diagnostic software, which insures correct weight of material only is lifted by it and if the load is excess or not properly packed, the material would be looped out for repair or change.

As the warehouse building is part of the ASRS itself due to rack supported warehouse concept, there is no movement of people possible within the ASRS which adds to further safety. Depending on the statutory requirement there can be fire detectors and fire protection system integrated with the ASRS for fire safety.

Typical construction details of rack supported warehouse

ROOF DETAILS – example with insulation
1. PVC membrane (t=1,2mm)
2. Insulation Paroc ROS 50, t=50mm (or similar)
3. Vapour barrier, Eurotex ALU (or similar)
4. Load bearing sheet, T45-30L-905/0,8mm, PE (plastic covered)
5. Roof structure
6. Fasteners (4 pcs per sheet)
7. Fasteners

Figure 6
EAVE DETAILS - example
1. PVC membrane (t=1,2mm)
2. Insulation paroc ROS 50, t=50mm
3. (or similar)
4. Vapour barrier, Eurotex AL (or similar)
5. Load bearing sheet, T45-30L-905 / 0,8mm
6. Roof structure
7. Fasteners
8. Column
9. Flashing
10. Flashing
11. Plywood
12. Flashing
13. Seal
14. Flashing (U102*40*1,0, Cover column end)
15. Net (cover between columns)
16. Fasteners

Figure 7

WALL DETAILS – example sheet wall
Cladding sheet detail
1. Thickness 0,8 mm
2. Z275 + PVDF

Figure 8
Design criteria - example

Designing rack supported building and cladding, wind load (shape of the building), terrain category and building class are the key factors.

### Design codes

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basis of structural design</td>
<td>EUROCODE 0</td>
<td></td>
</tr>
<tr>
<td>Loadings</td>
<td>EUROCODE 1</td>
<td></td>
</tr>
<tr>
<td>Steel structures</td>
<td>EUROCODE 3</td>
<td></td>
</tr>
<tr>
<td>Consequence class</td>
<td>CC2</td>
<td></td>
</tr>
</tbody>
</table>

### Wind load

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed</td>
<td>Vmax = 69 m/s</td>
<td>hurricane SS4 3 seconds gust value</td>
</tr>
<tr>
<td>Wind pressure design value</td>
<td>q = 1,25 x 69 x 69 / 2 = 3,0 kN/m²</td>
<td>No form factors, as 3 seconds gust value is taken</td>
</tr>
</tbody>
</table>

### Main dimensions

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length (X)</td>
<td>105 830 mm</td>
<td></td>
</tr>
<tr>
<td>Total height (Y)</td>
<td>27 530 mm</td>
<td></td>
</tr>
<tr>
<td>Total width (Z)</td>
<td>55 960 mm</td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td>163 000 m³</td>
<td></td>
</tr>
<tr>
<td>Floor area</td>
<td>5 922 m²</td>
<td></td>
</tr>
<tr>
<td>Wall area</td>
<td>8 300 m²</td>
<td></td>
</tr>
<tr>
<td>Roof area</td>
<td>6 100 m²</td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Rack supported Warehouse (RSW) Advantages

- Depreciation like in equipment (as a part of AS/RS)
- Turnkey solution
- Integrated easily with an AS/RS system
- Eliminates building columns since rack supports the structure
- Can be built at heights >100ft (30M)
- Inclement weather and seismic conditions have less impact on RSW
- Utilizes height instead of large land mass
- Improved energy efficiency
- Economical due to savings in cost of construction
- Lighter rafter and purlin sections due to close spacing of the racks
- Optimal spacing with high efficient material handling equipment like vertical stacker cranes
- No lighting required and may be required for the aisles for maintenance inspection
- No building columns interfere with the storage or material handling
- Shorter installation time
- Engineering and architectural time reduced

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