Designing Optimization: Creative Solutions in Pallet Storage Rack

By Patrick Thibault

The opportunity of improved space utilization

Nowhere in today's modern distribution centers is the concept of space utilization improvement given a more 'fertile field', than in the oldest and largest consumer of warehouse space; pallet-load storage.

The footprint devoted to such storage includes both the physical area that houses the palletized inventory and all access/perimeter aisles. The combination can typically reach 50% to 80% of the warehouse's total available floor space. In the facilities where pallet storage racking is installed as the primary means of storage, the opportunities to use available space more effectively expands significantly into the realm of true 'cube' space utilization of a building…length, width and height!

The first step in designing an effective and superior pallet storage system is to optimally combine the critical (but often opposing) functions of storage density and product selectivity. The factors to be considered for a balanced storage system include: the total number of SKU's which are palletized, the number which have threshold inventory quantities of more than one pallet load and up to or more than 20 pallet loads, rotation-of-stock (F.I.F.O.) requirements, and the methods by which product selection and replenishment will occur. High density storage enhances space utilization, but minimizes individual SKU pallet-load access. Direct 'face' access (selectivity) to all individual pallets typically requires more aisle floor space than high density storage arrays.

The importance of forklifts to rack system design

For many operations, a combination of highly dense pallet storage (floor bulk, drive-in & pallet-flow racks) and single-deep 'selective' rack, provides the best solution for accommodating large and diverse SKU bases that have a wide range of 'in-stock' pallet loads per SKU. For other operations, the storage systems design is driven by space factors; such as using the maximum available storage height of the building, combined with the least amount of aisle square footage. This alternative requires specialized forklifts that extend higher and require smaller aisle widths than conventional forklifts. In this application it is also common to use less floor bulk storage due to the height limitations of conventional counter-balanced forklifts or the need for individual pallet load access (selectivity), regardless of any individual SKU's pallet count.

The typical rack layout will fall into one of these three configurations: Standard Aisle (10'+ wide), Narrow Aisle (8'-9' wide) and Very Narrow Aisle (VNA 7' or less). These aisle-width classifications are more about the type, features and capabilities of the forklifts used to access pallet locations. Standard Aisle rack layouts typically utilize right-angle stacking, counter-balanced forklifts, such as 3 or 4-wheel 'sit-down' forklifts and 3-wheel 'stand-up' trucks. Narrow Aisle forklifts are also right-angle stacking forklifts, but use 'front-end' outriggers for stability, which makes the overall combined length of forklift and pallet load less than for the standard aisle forklifts. The VNA rack layout employs 'swing' (or pivoting) forklift mast technology, which negates having to turn the entire forklift at a right angle to the rack during pallet put-away & retrieval.

Pallet-load forklifts can be either 'man-up' (where the operator compartment elevates with the pallet-fork assembly) or 'man-down' (operator at ground level). These VNA trucks also may be equipped with 'guidance' systems that uses a floor-embedded wire system which allows for increased travel speeds, reduced steering demands and enhanced safety. In warehouse forklift technology, a decrease in aisle size is accompanied by an increase in forklift investment. The added advantage in going 'narrow' is to also go higher; the combined result yielding a significant increase in space utilization (smaller storage footprint or added storage in a similar size footprint, as compared to wider aisle applications).

Current challenges & challenging old conventions

The challenge of providing the best available rack layout solution is to maximize the number of usable storage locations given the parameters of pallet load dimensions, required minimum forklift aisle widths for the particular forklift/pallet load, roof-support column locations, height restrictions (building or forklift), physical obstructions (building stability bracing, overhead lighting/piping, floor grating/access plates, etc.), building/fire code regulations, and cost.

If the building for which the storage system is to be designed has not yet been selected or built, the rack layout may impact the selection or design of a future facility, since certain roof-support column placements can compromise even the most creative pallet rack layout design. However, this is more the exception than the rule, and usually the task is to find the best available layout for the 'current condition' parameters. Indeed, several alternative layouts may be required in order to ascertain the optimal cost-benefit ratio of the various forklift/storage location combinations.

The key factor in designing rack layouts is in knowing that pallet load dimensions, along with forklift aisle requirements, are often far more important considerations than the roof-support column locations. Conventional wisdom has long sought to first isolate these key building structures by locating them in the 'flu' space between two connected rows of racks and then adjust aisle widths, and intermediate pallet rack rows, accordingly. The intent suggests to protect the columns with the rack and to not block any usable pallet storage locations.

Unfortunately, this method can be the greatest deterrent to increased space utilization in rack system design! The first problem is that it disregards the 'best practice' to always maintain minimal, uniform aisle widths throughout the warehouse. The benefits of doing so are: better space efficiency, improved forklift operator productivity and decreased rack damage (as operators learn to perform consistent, repetitive forklift maneuvers in aisles of standard widths). At issue, is that this method supports a popular myth in rack design…that to purposely obstruct pallet storage locations is a bad thing. Contrarily, by maintaining minimum aisle widths and forgoing old conventions about locating roof-support columns located <u>only</u> in connected rack row 'flu' spaces, it is possible to exact additional rows of rack from the available warehouse space, providing a net gain in pallet locations that can be many times more than the number of those pallet locations that were obstructed in the more creative design alternative.

Rack layout design, even in the largest of 'big box' warehouses, is truly a 'game of inches'. While it remains important to not expose roof-support columns to the potential for forklift impact damage, many creative rack system designs use building column lines as 'borders'. The detailed design work must consider any interference with rack and columns, but the primary goal remains to optimize storage locations without having roof-support columns in forklift aisles that maintain standard (minimal) widths. That done, the only variable that remains, is the pallet rack itself.

Finding the optimal rack layout; a creative process

While it is true that many rack system layouts will follow the roof-support column pattern in a precise and workable manner, it is also true that many times the application demands are seemingly incompatible with the building specs. In these situations, an experienced professional needs to apply appropriate design methods, in an effort to devise a reasonable solution.

The process begins by verifying all pertinent details of the building, pallet loads, potential forklifts and expected-use of any bulk storage. The focus here is not isolated specifications alone, but any ranges, deviations or revisions that should also be incorporated. A good example is that of forklift aisles. Although they are to be uniform in width, they typically are made 'fixed' within a range of + 5% to 7% of their prescribed norm. Battery box sizes and attachments, as well as front/rear pallet load 'overhang' , can impact the aisle width requirement. The next step in the process is to apply a preferred pattern of rack/aisles to a small section of the warehouse (2 column bays, at minimum, starting one or more building bays from a parallel-running wall). The information gathered here is crucial. If this test fails, in that one of the 3 column lines is exposed (ending up in an aisle), then the same test should be re-run using different starting positions (at least 4' from the original test's start point). Results from this test will determine if more advanced methods are required.

The advanced methods that follow, necessary to find the optimal rack layout solution, include various ways of modifying the width footprint of designated rack segments within the overall pallet rack layout. Often, it becomes necessary to add small amounts of expanded-depth rack in order for a rack design to work as intended. This can be as insignificant as changing the 'row spacer' connector length between two back-to-back rows of single-deep 'selective' rack, or as important as substituting a deeper storage rack , like 'deep-reach' selective rack or 'push-back' rack. The most popular rack width modifier is to reduce a back-to-back row of rack to a single row. On the rare occasion, consideration for rotating the entire rack system 90 degrees may be required. There is no denying that a certain amount of creativity goes into the search for an optimal design, but it is a creativity born from experience.

The accomplishment of the ultimate goal is often based on determining repeatable patterns within the overall rack layout and mirroring those patterns from one or more focal points within the building. (This is likened to a butterfly or inkblot pattern … as created when a partial rack design is 'folded' out from a center 'focal' location). The design skill here is in determining the locations and frequency of the pattern centers throughout a given building. Of course, it is important to provide cost-justifications, in terms of a benefit analysis, for any proposed solution.

By way of example, the attached depicts a rack system solution that includes strategically placed 2-deep 'push-back' rack connected (back-to-back) with a single-deep selective rack. A 2-deep selective rack could have also worked in lieu of the 'push-back rack. However, 2-deep selective rack also requires that a 'deep-reach forklift' be part of the fleet. While the 'push-back' solution is more costly for the rack purchase, it has the added benefits of: 1) not requiring that one or more forklifts have a special deep-reach feature; 2) it is usable in a VNA application (where the first alternative would not); and 3) the 'push-back' rack is self- replenishing once the front location is depleted, thereby promoting more efficient picking. Keep in mind that this particular use of a deeper storage is intended to be sporadic, but at the same time is justified in its nominal use by Pareto's Principal of distribution (also called the 80/20 rule). When applied here, it suggests that most inventories have within them multiple pallet SKU's; in sufficient numbers (20%), to allow for modest amounts rack having '2-deep' storage locations.

Other factors of the design

The details of an effective rack design also extend to the vertical dimension.

Beam level positioning should account for more than just pallet-load heights and an industry-standard 'lift-off'' space (4"). Often, additional lift-off space is required, as in reach forklift applications where then its' outrigger inside dimension is narrower than the width of the pallet load; thus requiring the operator to perform an "up and over" pallet maneuver, to clear the 5-1/2" tall outrigger height, when placing or extracting a ground level pallet load. Also, at beam levels above 20' it is usually necessary to increase the "lift-off" space for any forklift application due to the 'tilting' the load, mast deflection and reduced visual acuity of the operator at such vertical distances between him/her and the higher level pallet locations.

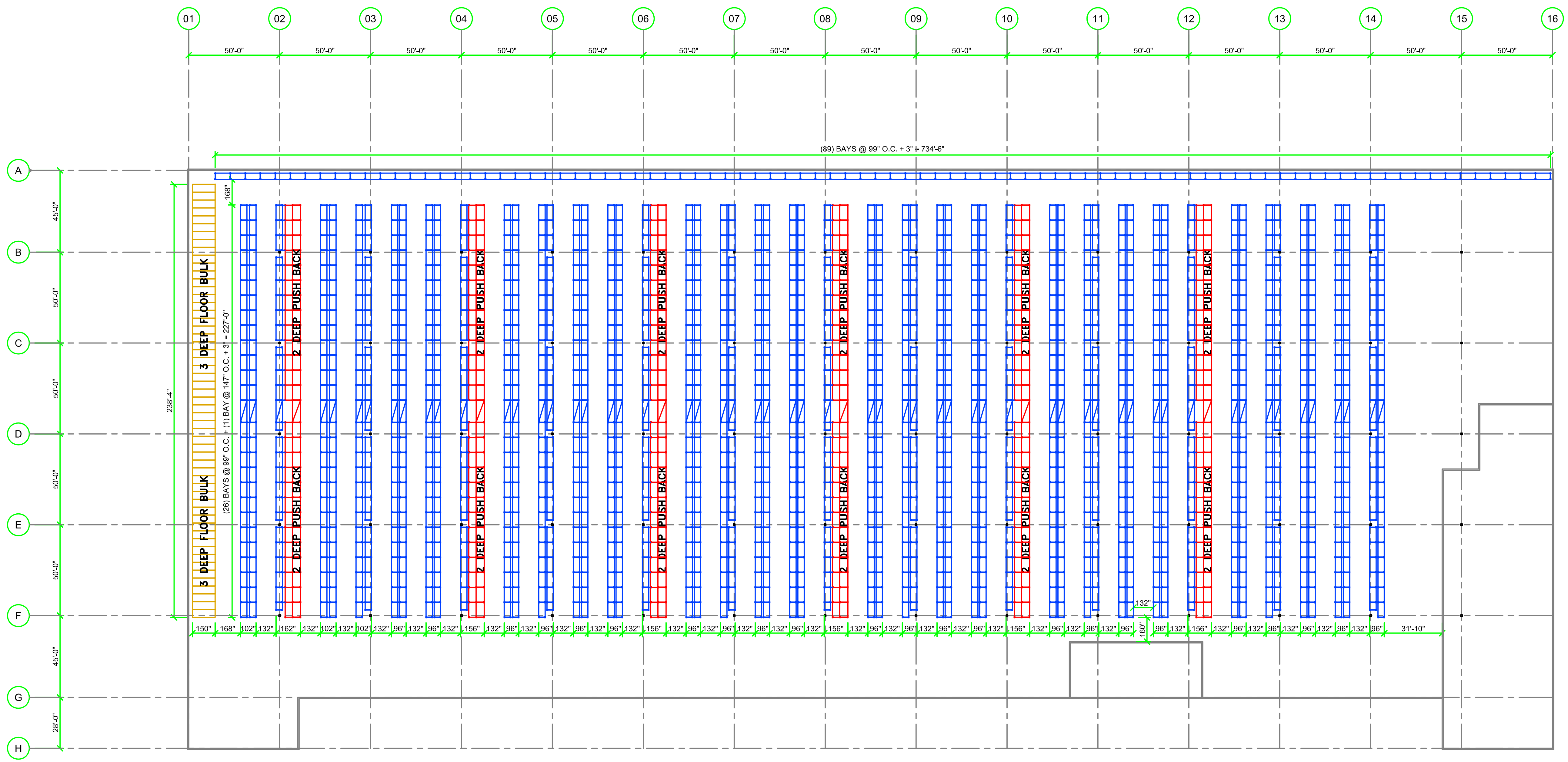
Additional considerations in pallet storage rack system design include several items related to building and fire codes (seismic stability, floor slab strength, longitudinal & transverse flu spaces, maximum storage heights, egress path code compliance, in-rack and overhead fire sprinkler protection). In addition, pallet-storage rack systems must also consider lighting, rack load capacity & directional signage, storage location labeling/bar code identification, forklift impact protection devices, in-floor wire/rail guidance systems and a host of accessory features of the rack itself. Furthermore, it must be code compliant and provide protection from impact damage that might otherwise render the system structurally noncompliant. Finally, it should promote both operator effectiveness and personal safety.

In the current LEAN thinking business environment, where purpose, process and people are the building blocks which transform ideals from maximization to optimization, the approach of creating a customized, 'best solution' pallet-load storage systems for each client is well suited to that LEAN agenda This can be especially effective when planning relocations or expansions to new facilities, where racking expertise can make all the difference in determining the storage system application which brings the best solution for the client's operational challenges.

Note: The attached exhibit depicts a 'real world' application drawing of a pallet rack system that uses 11ft wide aisles with roof support columns on 50ft centers. These columns are located near the aisle side face of the rack, causing a loss of pallet positions that is equivalent to 26 full bays of rack. The amount of additional rack that was made by this design is 162 bays, or an increase of 136 bays.

The six rows of 2-deep push-back rack represents 9% of all bays and 16% of all stored pallets, including floor bulk. (This analysis does not consider the 'conventional' rack layout which would have shown all the roof- support columns in the flu space of 2 connected rows of rack, resulting in 17' wide aisles and considerably fewer rows of rack, only the additions of the 2-deep 'push-back' rack).

Patrick J. Thibault is General Manager, Chino Division for Wynright Corporation's Engineering and Integration Group. Pat has nearly two dozen years in sales and management, and has focused on the material handling industry. He holds a B.S. degree in business administration and specializes in design, sales and implementation of rack systems.



REV	DESCRIPTION	DATE	BY	ENGINEERING APPROVAL BY
				X ____ DATE: ____
				CUSTOMER APPROVAL BY
				X ____ DATE: ____
				CUSTOMER APPROVAL WITH CORRECTIONS AS NOTED BY
				X ____ DATE: ____

Wynright
Engineers & Integrators
14373 TELEPHONE AVE
CHINO, CA 91710
MAIN:909.902.9880
FAX: 909.902.9660

PROJECT	DRAWING SPECIFICATIONS	
DRAWING TITLE	JOB NUMBER	SHEET

SCALE	DRAWN BY	DATE	REVISION
1/32" = 1'-0"			

DESIGN PROCESS CHECKLIST

I. DATA COLLECTION AND ANALYSIS

A. Pallet Loads
1. Pallet Load Size (including any product overhang)
2. Pallet Load Weight (minimum, maximum and average)
3. Pallet Loads per SKU (<1, 1, 2-5, 6-19 and 20+)

B. Building
1. Roof Support Column Patterns
2. Overhead Fire Sprinkler Protection System (type, ht. of sprinkler heads)
3. Maximum available 'Top of Storage' Height (based upon ceiling structure clearances, fire protection system type/rating and commodity hazard classification)
4. Concrete Slab/Sub-Soil Data*
5. Seismic ('near-source' factor)*

C. Forklift
1. Existing Fleet (truck types, lift capacities, lift heights, right-angle turn distances)*
2. Potential Fleet (cost implications to augmenting or replacing the existing fleet)
3. Guidance Systems

II. DESIGN WORK

A. Prepare one or more rack layout designs for each potential forklift aisle type (Standard Width, Narrow Aisle and Very Narrow Aisle)

<u>Using the Following Standards</u>:
1. Use minimum standard aisle widths, based upon forklift type and pallet load depth
2. Maintain placement of rack adjacent to roof-support columns such that there is no encroachment of said columns into the aisles (leading edges of rack with overhang and roof-support columns, being identical, is acceptable).
3. Determine longest repeatable pattern of standard rack configuration/minimum aisle and if that pattern can be doubled by reflection at designated focal point.
4. Test this pattern at multiple focal points within the building.
5. Adjust rack depths (various methods) to enhance opportunities to 'capture' the roof-support columns.
6. Use Pareto's Principle of Distribution (80/20 Rule), along with pallet load quantity data, to support strategic placement of expanded rack depth to multiple pallets per location.

B. Fine Tune Layout
1. Vertical slot size adjustments for forklift and picking/putaway variables.
2. Cost-benefit analysis based upon storage locations, throughput capacities and alternative storage method costs.
3. Building and fire code-compliance analysis.

* These data items may affect overall feasibility of pallet storage system.