

## **JPL DISTRIBUTION CENTRE – WORLD LEADING CONCRETE FLOORING**

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### **SUMMARY**

The JPL distribution centre in East Tamaki incorporates a 25,000 m<sup>2</sup> post-tensioned ground floor, designed to facilitate the use of cutting edge logistics technology such as 16 m high Very Narrow Aisle Racking. The project required balancing the owner's requirement for an extremely durable and low maintenance surface with the need to optimize the floor flatness to support the day to day operation of the most modern material handling equipment in the world. Very Narrow Aisle facilities are becoming much more prevalent in New Zealand and the JPL distribution centre offers an excellent case study for examining some of the design and construction challenges these buildings pose, while also reviewing the marrying of New Zealand construction techniques with international best practice and recent global innovations in industrial flooring.

### **INTRODUCTION**

The James Pascoe Group distribution centre in Laidlaw Way, East Tamaki, consolidates warehousing and distribution for all of the groups brands which include Farmers, Whitcoulls, Stevens and Pascoes. Constructed over the course of 2014 and 2015 the new building, which is an extension to an existing warehouse, comprises a total floor area of 45,000 m<sup>2</sup>. This includes a 25,000 m<sup>2</sup> ground floor with a minimum 20 m roof height, 14,500 m<sup>2</sup> of a mezzanine floor level, and a multi-storey car park and photographic studio. The internal volume of the building is 6 storeys high, and it covers an area the size of three rugby fields.

Acting as both client and project manager James Pascoe Group was focused on long term business performance and not development profit. The goal of the project was to create a state of the art distribution centre to minimize costs and maximize value for customers by maintaining the highest "in stock" position possible for core merchandise. This was supported by introducing the latest warehousing systems and technology including 16 m high very narrow aisle (VNA) racking. The VNA racking and material handling equipment (MHE) required a level of floor flatness that is considered the highest in the world.

As the working surface in the distribution centre the concrete flooring played a pivotal role in achieving the twin goals of durability and material handling efficiency. These two priorities created a complex set of challenges and required the development of new technology mixed with the refinement of existing global best practice. This led to the achievement of a series of New Zealand firsts including the only internationally certified true super flat VNA floor the country, and the use of a movement joint detail that was specifically developed to mitigate slab curl.



Figure 1 James Pascoe Group introduced cutting edge logistics technology in order to create a state of the art facility. A key feature was the 16 m high VNA racking – the highest ever installed in New Zealand

### A CUTTING EDGE LOGISTICS FLOOR

In order to maximize the capacity of their new facility James Pascoe Group introduced the latest warehouse systems. The key feature of the facility was the use of nearly 2 km of 16 m high VNA racking aisles. VNA racking allows for much denser product storage compared to a conventional system by using significantly higher racking combined with a narrower aisle width. Material is handled by special equipment which operates semi-autonomously and is wired guided. In comparison to standard material handling equipment, VNA equipment will run on a fixed wheel path – akin to a train running on tracks, as opposed to traditional equipment that will operate more like a car does on the road. This characteristic of a VNA system, coupled with the narrow aisle width and high racking level require a different approach to floor flatness.

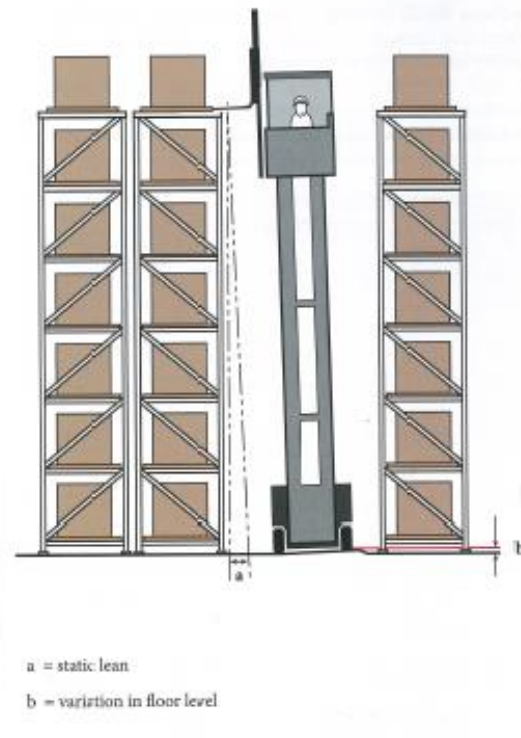


Figure 2 Small variations in floor level can cause large leans in VNA systems (The Concrete Society, 2013)

## Floor Flatness

These systems require exceedingly tight floor flatness in order to function. Any imperfection in the floor surface is magnified multiple times over when a forklift mast is operating at a 16 m height and attempting to place a 750 kg pallet precisely onto two rack beams. In fact a 2 mm difference in level across the narrow 1.7 m forklift wheelbase will create enough lean at 16 m that it becomes physically impossible to place a pallet. The current New Zealand standard for floor flatness – NZS3114:1987 (Standards New Zealand, 1987) isn't suitable for a modern logistics facility. As such an alternative internationally recognized specification was adopted for the JPL project, DM1 to TR34. The UK Concrete Society Report TR34 includes a special section covering floor flatness for VNA facilities (The Concrete Society, 2013). The flatness categories have been developed based on real world performance of VNA warehouses, and are accepted by all the key parties involved in delivering a successful VNA warehouse – the racking, material handling, and concrete flooring industries.

Adopting a proven standard for floor flatness is critical to the success of a modern warehouse project. Compared to NZS3114:1987 the flatness standard presented in TR34 has many benefits. It is calibrated to the actual requirements of the material handling industry, the flatness tolerances are achievable provided the correct construction methodology is adopted, and the surveying process is clearly defined and repeatable. None of these claims could be made for NZS3114:1987 which is somewhat unsurprisingly “showing its age”.

For VNA floors flatness is measured only along the specific wheel path the vehicle runs along – and controls for the tilt and “bumpiness” both along and across the aisle. These properties are measured using specialised equipment called a Profileograph (The Concrete Society, 2013). For the JPL project the equipment was sourced from FACE Consultants Pty in Australia. The Profileograph gives precise data of the profile of the floor at 50 mm increments along each wheel path.

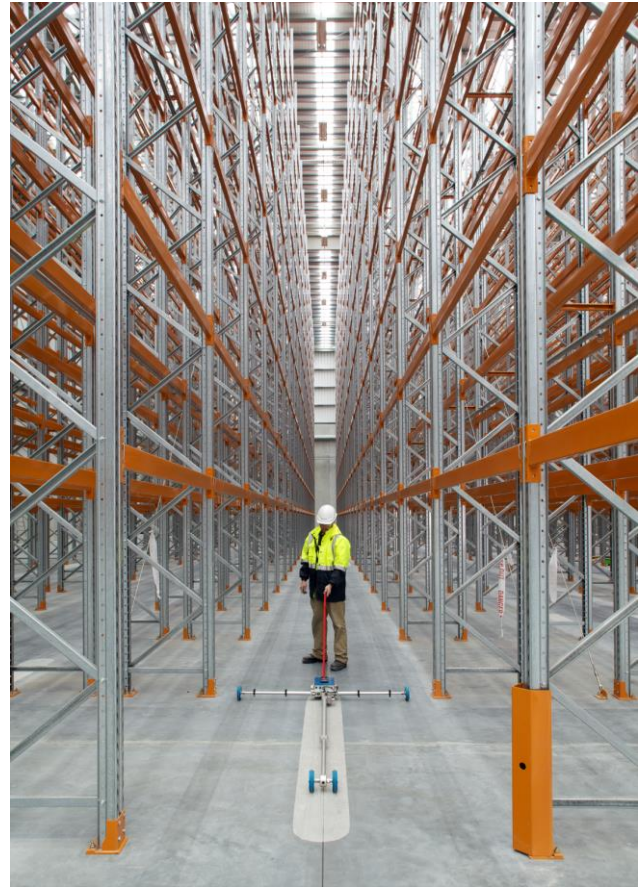


Figure 3 FACE Consultants Profileograph surveying of the JPL Distribution Centre

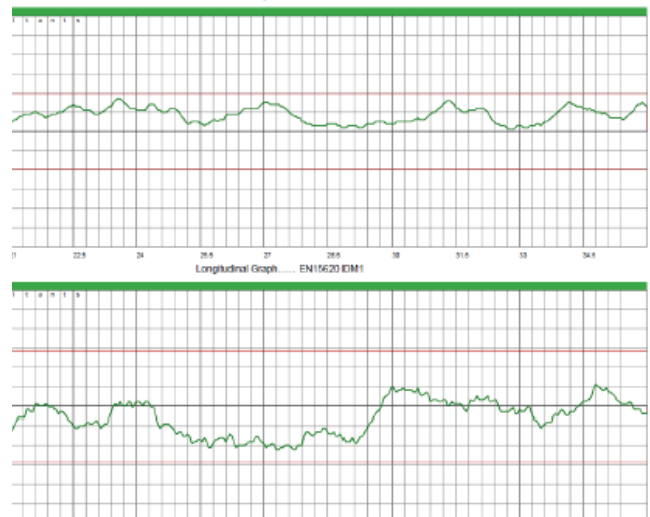
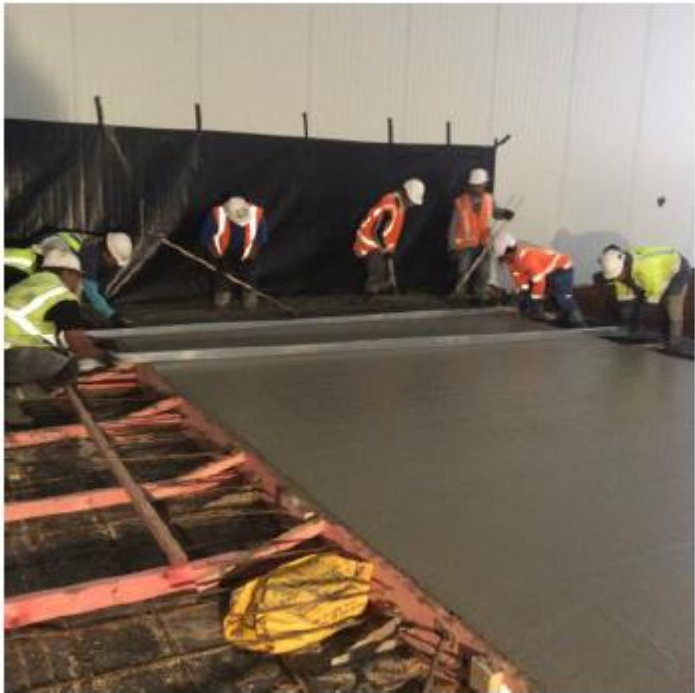


Figure 4 Sample data from a Profileograph survey

Achieving “Superflat” VNA floor flatness tolerances

In order to achieve the tight tolerances required in a VNA facility the traditional construction methodology is to build a single aisle at a time, levelling the floor off accurately placed formwork set on either side of the aisle. This approach was not well suited to the new James Pascoe Group Facility. It would lead to the introduction of a plethora of joints and saw cuts that would require a lifetime of maintenance, and create the potential for joint curl to disrupt traffic after the facility was operational. Joints and saw cuts are weak points in a floor that tend to spall and fail under heavy use. This traditional narrow strip construction method is also exceedingly slow and would not meet fast track program requirements. It would also require the use of a less efficient floor design which would require a much larger volume of concrete and therefore present a less sustainable solution.



## CREATING A DURABLE FLOOR WITH VNA FLATNESS

In order to meet the dual requirement for a durable and maintenance free floor with exacting VNA flatness requirements the project team developed a new world first hybrid approach to VNA floor construction. The floor was constructed as a series of large bay post-tensioned floors, coupled together so that there were only two opening joints located within the 25,000 m<sup>2</sup> ground floor. Combined with the use of a new system for concrete floor jointing – the Rhino joint, this create a surface that would require little to no maintenance during the life of the structure. The use of post-tensioning allowed for an efficient and relatively thin 240 mm thick floor to cater to the 120 kN back to back rack loading, thereby reducing the volume of materials and subsequent CO2 emissions compared to a traditional floor system.



Figure 6 Large bay post-tensioned floor pour at JPL

The layout of floor pours was optimized to suit both the racking layout and the placing and finishing process that Conslab developed for the floor. This process involved the refinement of Somero Laser Screed techniques to strike off and level the floor, along with a tightly controlled system of straight edging and ride on power trowel finishing. The concrete mix design was optimized to support this process by providing the best possible window of finishability while still meeting the structural and durability requirements of the project. Attention was paid to limiting the variability as much as possible and so the slump (used as a proxy measurement for set time) was controlled rigidly for every load of concrete delivered to site, and the floor construction was programmed to take place in a weather tight and windproof building to limit environmental variability.

The trade off of constructing the floor in large bays was that the finishing process could no longer be optimized to focus on individual VNA aisles. The benefit of the traditional approach of constructing VNA floors in long narrow strips is that the floor flatness can be controlled meticulously in the one location that really matters – the aisle. In contrast when constructing using a large bay approach the floor can achieve a very high overall standard of flatness, but

will still contain areas in aisles that fall outside of a VNA specification. These areas were addressed by grinding along the fixed MHE wheel paths to bring them into tolerance. While grinding the surface in these locations can be unsightly and reduce surface durability this downside is more than made up for by the key benefits of using a large post-tensioned floor - a more efficient structural design, superior MHE performance due to minimal construction joints, and the complete elimination of saw cuts which are the most common long term maintenance issue in floors.

The initial goal was to construct the floor to the highest level of “general” flatness classification in TR34 – FM1. This classification applies to the floor as a whole, and not just the specific VNA aisles. The tighter VNA tolerance was then applied specifically to the aisles. This was the DM1 specification from TR34. This specification is recognized as the tightest VNA flatness standard that is achievable in the world. Some of the tolerances are so tight that a few sheets of paper placed on the floor might make a difference between a pass and a fail. Due to the high quality construction of the original surface as little as 20-30% of the aisle length required grinding to achieve the optimal surface profile.

### Mitigating Curl

Slab curling can present a significant issue in a high quality warehouse floor by creating an out of tolerance surface at joints, or reducing load capacity when a curled joint loses contact with the sub-base (Garber, 2006). Curl is the result of differential moisture and temperature profiles in a floor (Garber, 2006). In New Zealand where internal floors are constructed on an impermeable damp proof membrane floors curl upwards at joints. Like drying shrinkage, curl in concrete slabs on grade should be seen as a given (Garber, 2006), however in the authors experience the relatively high shrinkage concrete in New Zealand (due to the use of elastic aggregates) exacerbates the issue compared to other markets. Contrary to a commonly held misconception the use of dowels will not mitigate curl at construction joints although they will help reduce the risk of failure due to loading of a curled joint (Garber, 2006).



Figure 7 Slab curl in a typical New Zealand floor

For a facility such as the JPL distribution centre curl would be a significant issue – it would compromise the floor flatness required for the cutting edge VNA system, and could present a significant maintenance burden over the life time of the building. To mitigate the issue of slab curl the number of opening joints in the floor was minimized by using a post-tensioned floor design. The joints that were required were then installed in the lowest traffic areas possible, and a special New Zealand designed joint system called “Rhino Joint” was installed. The Rhino joint resists and prevents the typical upward curl through by creating an anchoring force on the top edge of the slab.

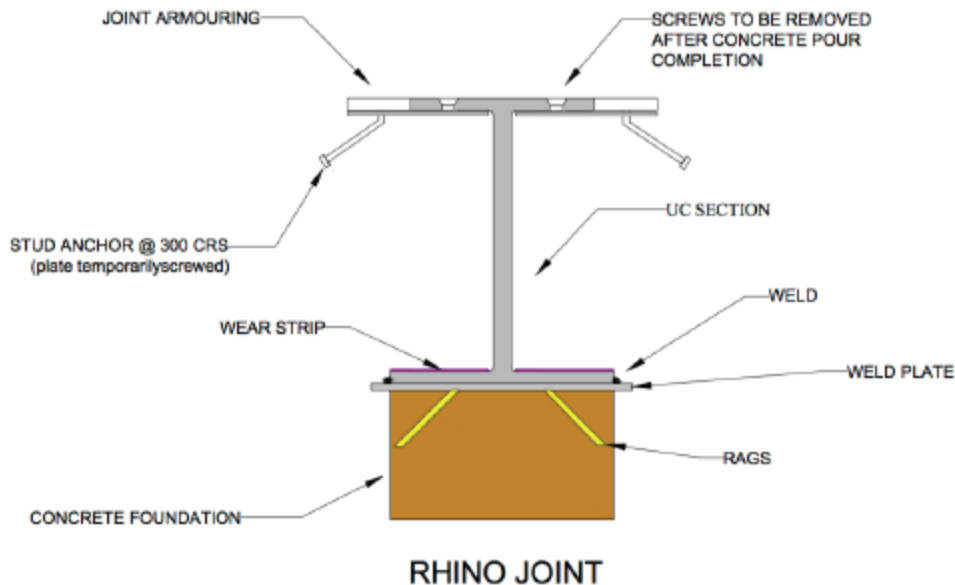


Figure 8 The NZ designed "Rhino Joint" is a patented movement joint system that prevents slab curl by restricting upwards movement.

## KEY PROJECT OUTCOMES

In order to create a state of the art distribution centre James Pascoe Group required an exceptional concrete floor that would be durable and maintenance free, while providing an extremely flat surface for the highest VNA racking system installed in the southern hemisphere to date. The 25,000 m<sup>2</sup> floor incorporated a variety of innovations and unique features.

### An Innovative Approach to Constructing a VNA Floor

Because a traditional “narrow strip” floor construction process would slow down program, thicken the floor, and make it weaker and more prone to maintenance the project team developed a large bay post-tensioned solution which:

- Minimized joints – the floor required only two opening joints within the 25,000 m<sup>2</sup> area. Joints and saw cuts represent weak points in a floor that require regular maintenance, and disrupt MHE operation. It is estimated that this could save in excess of \$500,000 of maintenance costs over a 20 year period.
- Allowed fast construction – The 25,000 m<sup>2</sup> area could be constructed and ready for racking in under 100 days, saving approximately 20 – 30 days compared to a conventional solution.

- Provided a more sustainable solution by minimizing concrete volumes. For the 120 kN back to back rack loading (effectively a 240 kN point load) a traditionally designed New Zealand floor would likely require a thickness greater than 300 mm (CCANZ, 2001). In contrast the post-tensioned solution was 240 mm thick – reducing the consumption of concrete by at least 20%.
- The combination of faster construction time and a more efficient use of materials resulted in an approximate 25% reduction in construction cost.

### A New Zealand First – A True Superflat VNA Floor Surface

The current New Zealand standard for floor surface finish and flatness (NZS3114:1987) (Standards New Zealand, 1987) is not suitable for the requirements of a modern logistics warehouse. In order to meet the clients exacting requirements the project team:

- Introduced a European standard (The Concrete Society, 2013) that integrates floor flatness, racking and MHE tolerances in order to control the interface risk between these elements and specify a floor finish that would support 16 m high VNA racking.
- Used special profiling/surveying technology to map the exact pathway that MHE would run down in every aisle to be able to confirm compliance.
- Refined a Somero Laser Screed placing and finishing process, and carefully planned and controlled key variables that impact surface finish – such as concrete mix design, environmental conditions, and the sequencing and detailing of pour layouts.
- As a result of this process, the floor achieved the highest general flatness category of FM1 in key racking areas, and only required approximately 20-30% aisle grinding to achieve the highest recognized VNA flatness standard in the world – DM1.

### Producing a Durable Surface

Because of the building owner's desire for a highly durable asset serious consideration was given to producing a low/no maintenance floor. This involved several critical steps:

- The finishing process, high level of workmanship and optimization of the concrete mix design combined to provide a dense and abrasion resistant surface.
- The floor was designed to contain the minimum number of opening joints. Joints are the critical source of maintenance in a concrete floor. Where joints were required the layout was optimized to match the racking layout. This minimized the length of trafficable joint further reducing the potential for maintenance.
- A new joint design, the Rhino joint, was used. This joint system resists upward movement of the joint to mitigate slab curl. Slab curl is a common form of failure in concrete slabs on grade (Garber, 2006), and up until this point has been virtually impossible to eliminate in large joint openings such as those seen in a post-tensioned floor.

## **REFERENCES**

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