

Post Tensioning Awards 2010



New Manufacturing Facility, Steetley, Worksop

Project Summary

The building is 166m long x 151m wide x 19m high, adopted a grid of 15m x (20-26m). The project comprises construction of the Manufacturing facility with mezzanine floor, a welfare office building (a 3-storey structure 250/375mm thick P-T slabs with RC infill areas), a batching plant, and ancillary buildings.

Location	Worksop, Nottinghamshire
Year of completion	2009
Type of structure	Industrial – Slab on ground
Project Size	24,600 sq m.
Total Project Cost	£57M (approx.)
Owner	Laing O'Rourke Manufacturing
Architect	CPMG
Consultants	Waterman Structures
Main Contractor	Laing O'Rourke
Frame Contractor	Expanded Structures
PT Contractor	STRONGFORCE – A Division of Expanded Limited
PT Designer	Alliance Design UK Ltd
PT System	Bonded Flat Duct 3-4-5 MonoStrand system (12.9mm)
PT tonnage	135 Metric Tonnes
Project Duration for PT works	29 weeks

Post Tensioned Slab on Ground for Precast Manufacturing Unit

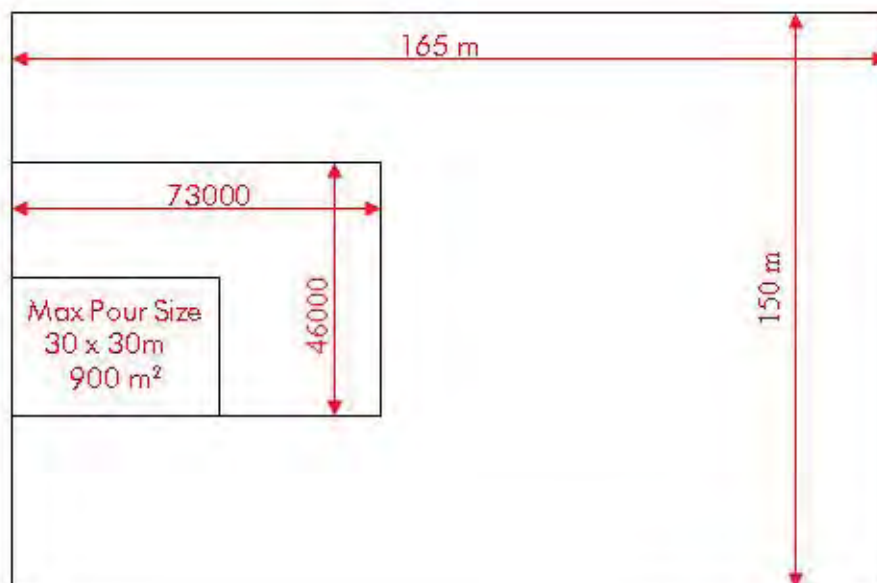
Why Post-tensioned Solution For Slab On Ground?

The PT slab on ground provided a solution with short and long term benefit to the project. Manufacturing operations being the priority, we have contributed to this function by providing an economic structure which gives the client flexibility of layout and floor use. The visible saving is in materials, where the 180 thick PT slab had an advantage over the 300 thick conventionally reinforcement solution, while efficiency is in the design where the concrete and sub grade properties are optimised.

The success of the solution must also acknowledge the collaboration between design and construction. Maintaining coordination where the equipment design development strongly influences construction is challenging and ensured that the design would not just be a flat rectangular ground slab. Pour sequencing, and program coordination enabled many of the advantages of the PT system to be realised.

Advantages: -

- Accommodates differing load arrangements (Racking, Traffic, Machinery) and magnitudes
- Reduced slab thickness to maintain shear and flexure actions due to the pre-compression imposed by the post tensioning
- Less reliance on ground improvement to achieve required load distribution under traffic and cyclic loadings.
- Program savings by reduction in ground excavation, material to be placed and fixing time of reduced quantity of reinforcement.
- Sustainable benefit of meeting design requirement with less concrete and less manufactured steel
- Improved crack control and resistance to shrinkage effects
- Large pour sizes and reduction in construction joints
- Large flat slab areas of uniform finish and level without differential settlement across joints.
- Reduction in number of movement joints and life cycle costs in maintaining them.



Loadings

Defined zones 1 and 2 below became the principal criteria and were adopted throughout.

Zone 1 – Racking / storage / warehousing	<ul style="list-style-type: none">• Concentrated arrangement of high point loads, close spacing or support of rail tracks carrying materials.• Requires the slab to have a punching shear capacity under nominated base plates and control of differential flexure and deflection under cases of patterned point loads.• Design criteria defined the loads and spacing however the requirement remained for future flexibility and point load case of 100kN at 2m centres was adopted throughout and this load specification formed the basis for the initial depth and PT quantity proposed for the solution.• Shear capacity was provided based on an unreinforced section with enhanced tensile capacity provided by the pre-compression.
Zone 2 - Traffic / delivery / forklift	<ul style="list-style-type: none">• Designed to accommodate forklift traffic (more frequently applied dynamic load capacity).• For HA highway loadings the elastic performance of the slab was modelled with multiple combinations.• Fatigue and load cycles applied to the slab at road parameters.
Zone 3 - Peak support loads / Machinery loads	<ul style="list-style-type: none">• A number of areas were nominated for very strict settlement control under peak point loads.• In particular at machinery supports with loads up to 650 kN where thicker slab was designed as Post Tensioned raft foundations. Tendons in these zones were located closer to the bottom of the slab to assist in deflection and control of tensile forces under the loads.
Zone 4 - Steel frame supports	<ul style="list-style-type: none">• Supports to the main frame were provided independent of PT slab and were isolated from it.

Design

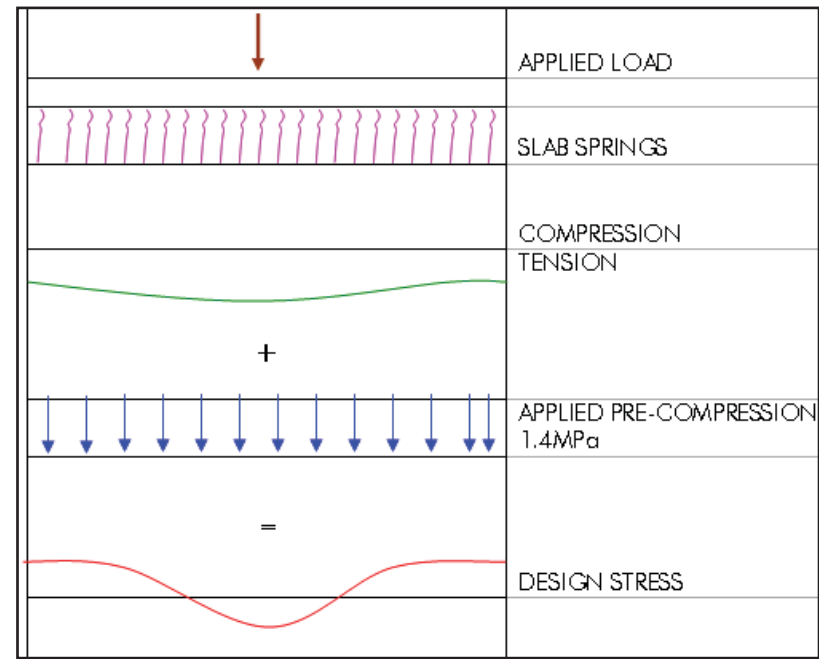
In the service condition the slab maintains an even settlement profile and limits differential movement under patterned point loads. It also resists actions which lead to cracking and the need for jointing. Strength conditions require the slab to sustain concentrated point loads and have capacity in flexure to support the tension stresses as the sub grade deforms under the load.



Critical in above assessment is the geotechnical properties of the sub grade, more so the sub grade modulus, which determines the spring support stiffness to the ground slab.

The initial investigation considered the slab to be cast over a rock base with a high modulus of 200 MN/m2 which implied the sub grade would take all the load and a slab design purely to reduce joints and enhance crack control.

Further investigation identified a reduced reaction where the footprint of the building extended of areas of structural fill. In these areas the sub-grade modulus was defined as 30 MN/m2, an 85% reduction. This was the design criteria adopted across the full site and the ground slab would now have a greater requirement to distribute load.



The design of bonded PT slab is intended to be unreinforced other than the tendons and utilises the basic principal of PT which is pre-compression. The tendons are placed flat at the centroid of the section to impose an axial pre-compression across the slab. The compression offsets the development of tension within the concrete section. The tension development in this case is limited to the unreinforced limit of TR43 of 0.3fctm. This is at peak load points and is otherwise maintained in compression.

Shear checks under point loads consider a concrete and stress component, ignoring bonded reinforcement. While

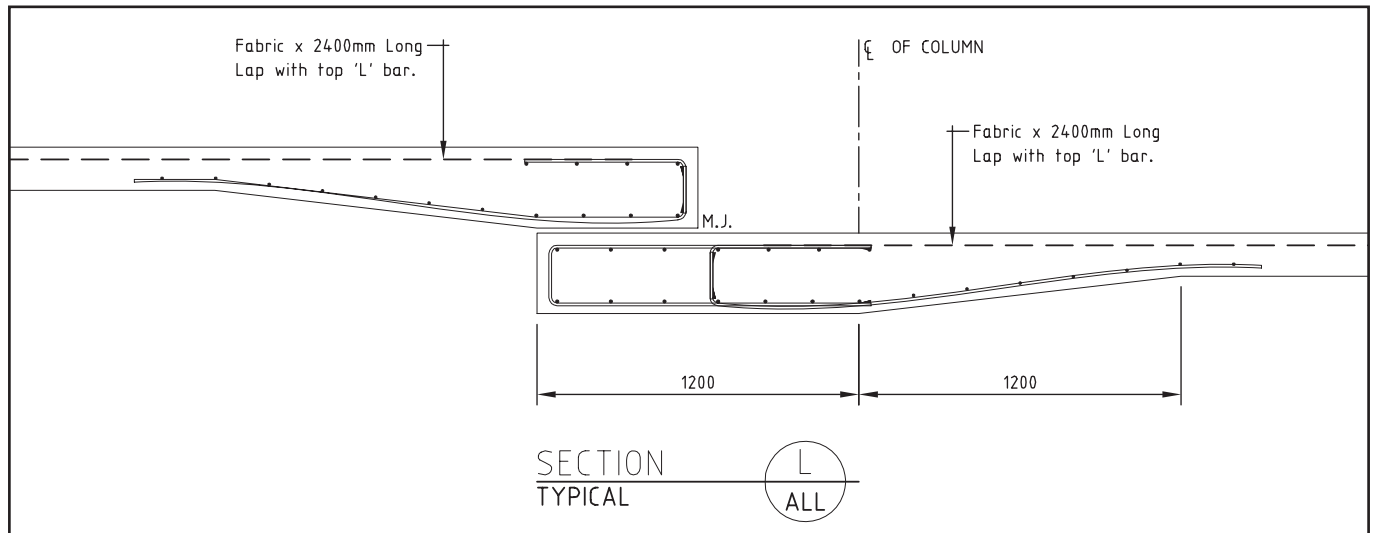
bonded tendons can provide an area of design reinforcement, the random application of load and the reduced effective depth at mid height make it more appropriate to ignore. Loads adjacent to slab edges will consider thickenings in the slab and perimeter reinforcement to increase capacity.

Finite element software enabled consideration of factors like pattern load cases; the slab support (grillage of springs of defined stiffness); short and long term losses used in suspended PT design. While the friction within the duct is reduced with a flat profile the friction between the slab and the ground will reduce the compression. This is reduced using multiple layers of DPM placed over a blinding layer of concrete.

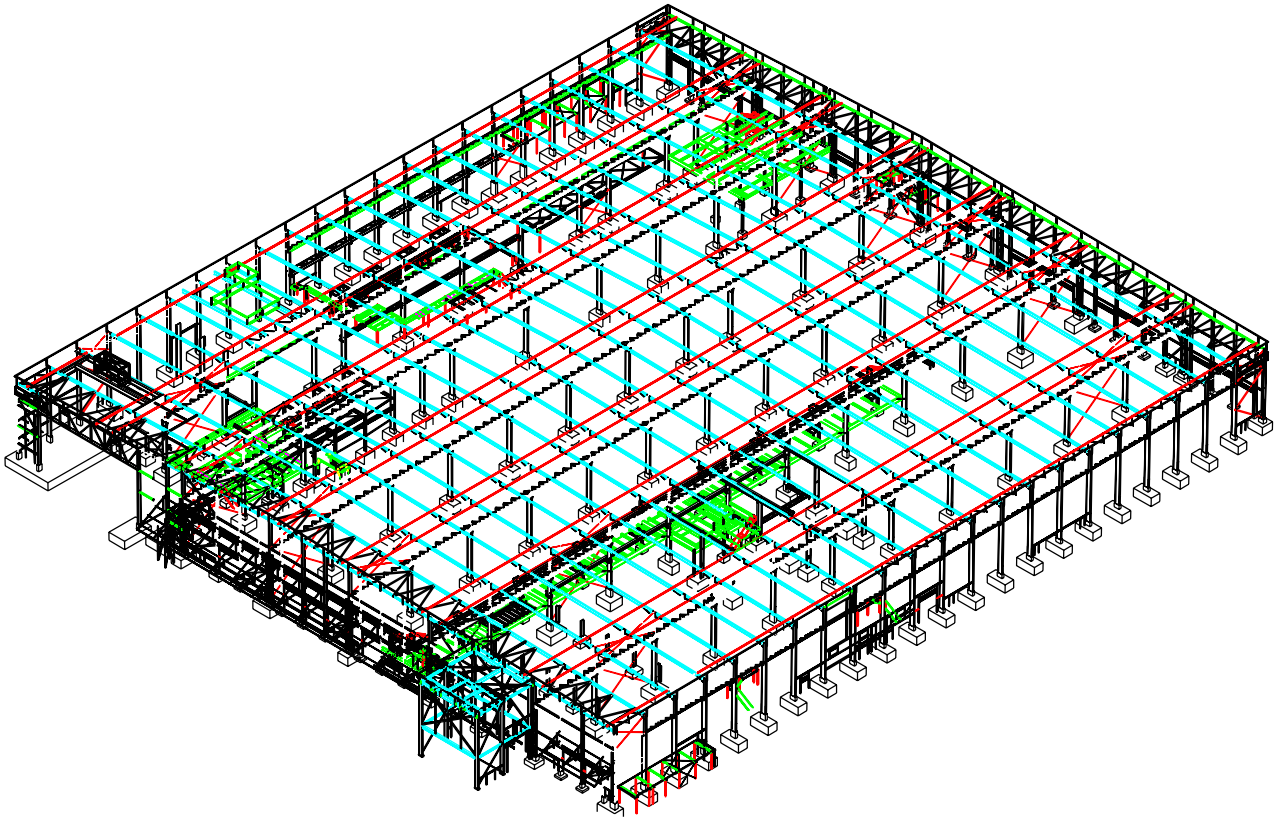
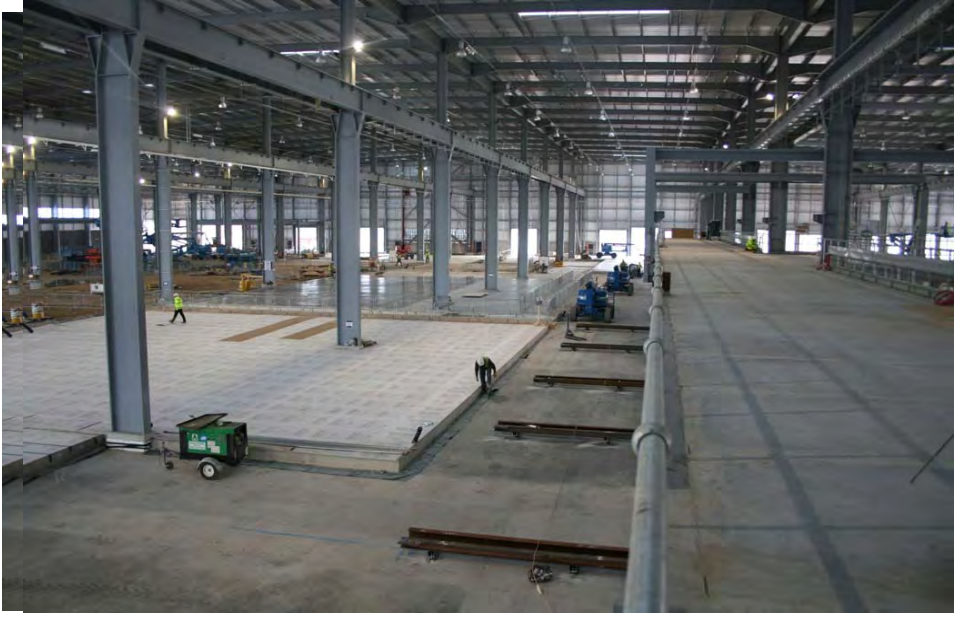
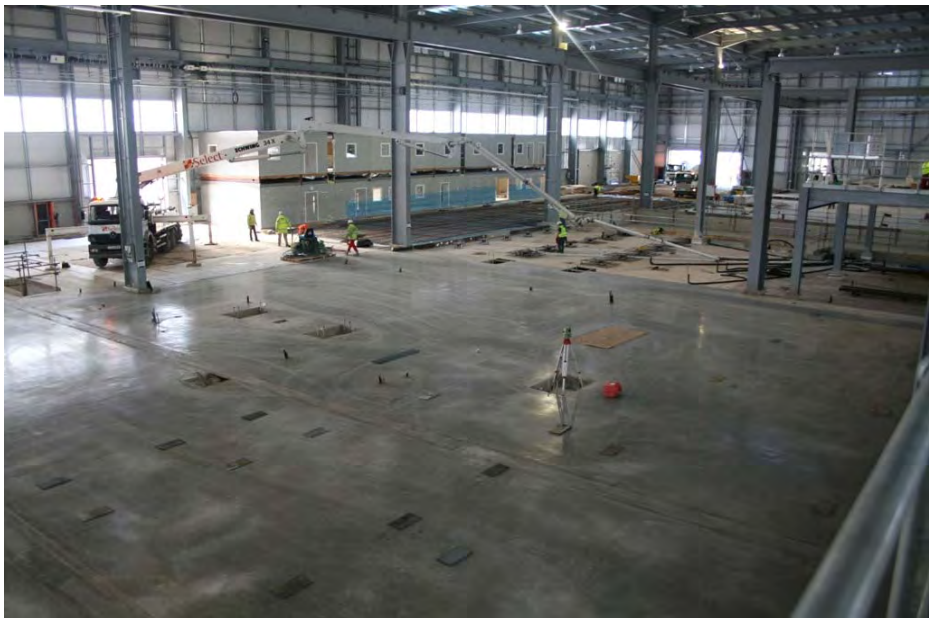
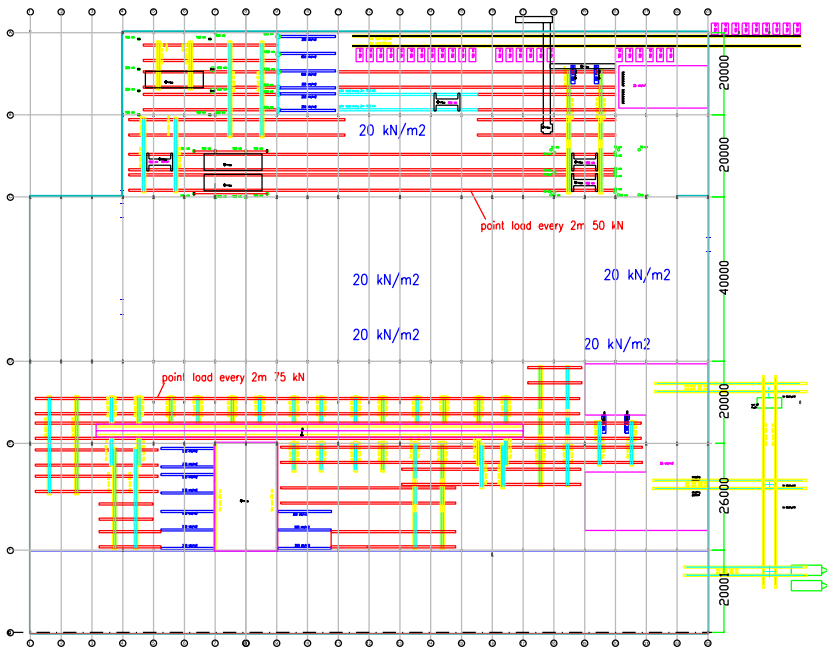


Layout

Restraint can reduce the level of pre-compression in slabs on ground and is often addressed with pour strips. Steetley being an industrial application had many pits and trenches, which would by default act as restraints to the ground slab. A feature of the pour layout and construction sequence at Steetley was the split level of the slabs. This allowed the low level equipment support slabs to be cast first, with pits acting as single restraint points un-opposed. High level slabs (+300mm) which were in delivery and access zones linked these areas but were overlapped without continuity and without restraint. This ensured that the high specification finish on the surface slabs was maintained over large areas with crack control and a minimum number of joints.



Post Tensioned Slab on Ground for Precast Manufacturing Unit



ADAPTED FOR PTA SUBMISSION 2010



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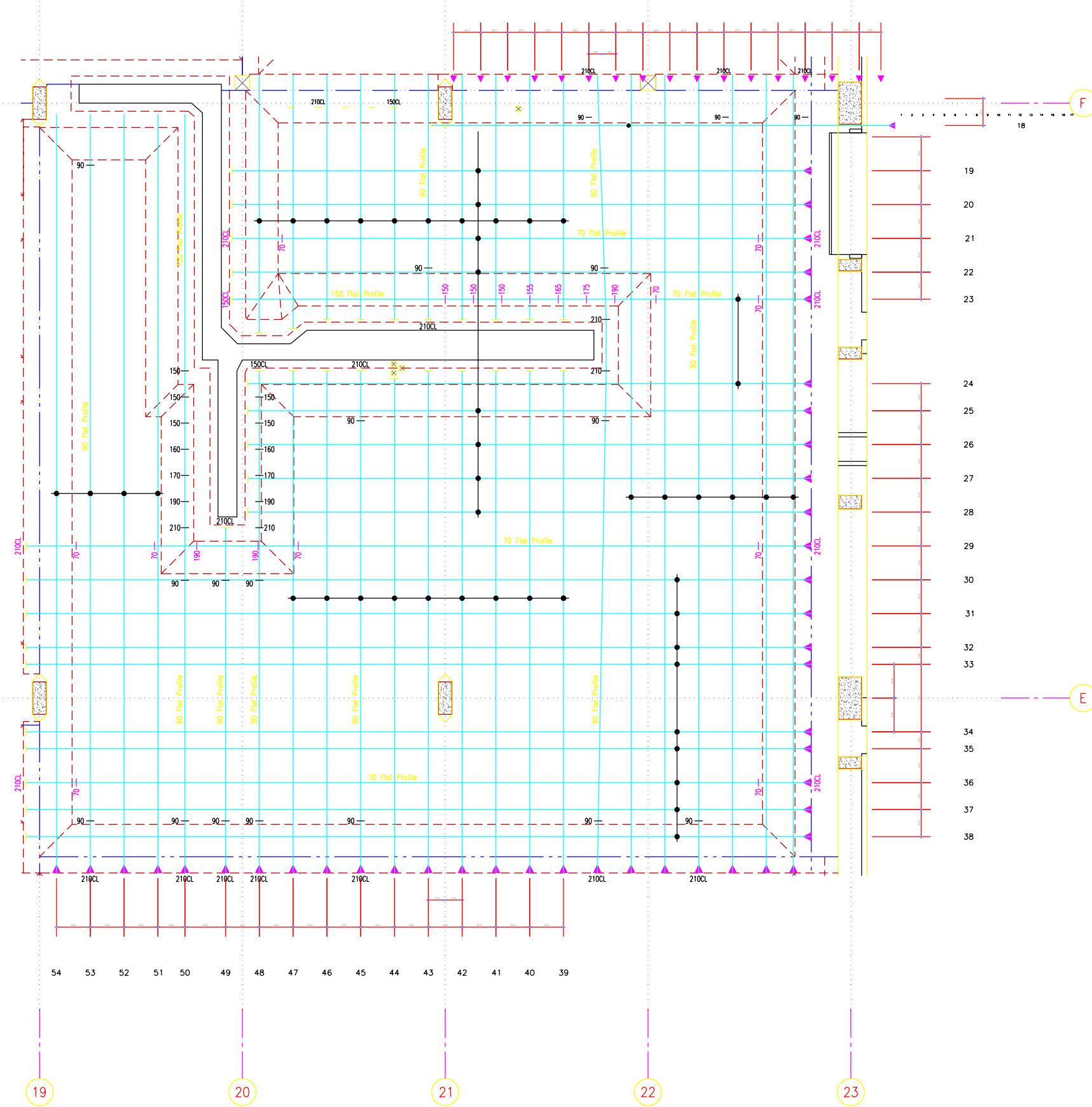
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Project
**NEW MANUFACTURING FACILITY
STEETLEY, WORKSOP**

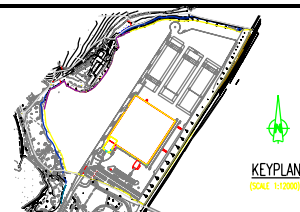
Drawing
LOADING PLAN AND SITE IMAGES

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Project

**NEW MANUFACTURING FACILITY
STEETLEY, WORKSOP**

Drawing

TYPICAL TENDON LAYOUT

SF-PTA-2010-SK-2



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