

RYAN COMPANIES US, INC.

BUILDING LASTING RELATIONSHIPS

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Multi-Story Building Staking and Control

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What is it?

- Layout of Building Structure Utilizing Boundary Survey From Construction Documents
 - Staking Deep Foundations
 - Layout of Foundations and Walls
 - Layout of Anchor Bolts and Embedded Items
 - Setting Bench Mark Elevations at Each Level
 - Plumbing of Structure during Erection
 - Establishing Horizontal Control (Grid Lines) at Each Level
 - Horizontal & Vertical Verification of Work in Progress

Key Differences From Land Surveying

- Its off the ground, If you are afraid of heights it may not be for you!
 - To perform multi story surveying and layout you will be required to work at building edges and in or next to building shafts
- Different safety requirements than land surveying
 - OSHA requires fall protection for anyone who is working 6' or more above a lower elevation
 - Falling objects; Surveyors will be required to work in dangerous areas where falling objects is a risk
 - Proper safety equipment will be required
- Shooting Vertical
 - Instruments are not always as accurate when shooting vertical
 - Precise level loops transferring elevations floor to floor

Key Differences From Land Surveying (continued)

- Tighter Tolerances
 - Typically building structural tolerance variation from plumb is 1/500 (1/4" in 10') not to exceed 1" in overall variation in any one direction (always consult with structural engineer)
 - Variation from level or from grade indicated is 1/4" in 10 feet, 1/2" per bay and 3/4" in maximum length of structure
 - Building Control should be as precise as possible as tolerance is needed for material installations
 - Tolerances can be used up in fabrication of materials, installation of materials, and material mill tolerances
 - Out of tolerance can also be the difference in building comfort or feel
 - Unevenness and or leaks in building exterior
 - Sloped or uneven floors
 - Rough elevator operation

Key Differences From land Surveying (continued)

- Tighter Tolerances (continued)
 - Can affect cost of project
 - Encroachment of property lines
 - Modification of fabricated materials
 - Extra engineering costs associated with fixes
 - Reinstallation of materials
 - Loss of rentable square feet in building
 - Restricted clearances in chases or openings
- Layout tasks a surveyor may be asked to do:
 - Set grid Lines and bench marks at each floor
 - Set anchor bolts
 - Layout of interior partitions
 - Verification of building components
 - Layout of mechanical/ electrical sleeves

“When contracted to do building layout, we are expected to perform these functions efficiently and accurately”

Things to Consider Preparing for Multi Story Layout

- Analyze the building site
 - Adjacent building interference
 - Where can I keep my points stable and protected?
 - Will sight lines be lost as building progresses in height?
- Deciding what method to use for building control
 - Bring vertical lines up internally or externally
 - If concrete core proceeds rest of structure, how will it be controlled?
 - When and what kind of control will be needed?
- Equipment to use
 - Theodolite
 - Total Station
 - Zenith Nadir
 - Automatic Level
 - Horizontal and Vertical Lasers
 - Measuring Chains
 - Plumb Bobs

Accuracy & Confirmation

- Always double check control, use alternative methods
- Understand Building Movement
 - Shoot control lines same time each day
 - Compensate for temperature coefficients
 - Do not establish control in extreme weather conditions
 - Consistently check established elevation points at base of building to check for foundation settlement
 - Bring elevations up from bottom every time
 - Review concrete creep and shrink compensation with structural engineer
 - Check elevation of steel column tops regularly to allow for adjustment
- Understand limitations of equipment
 - Be aware of heat distortion in optics or lasers
 - Always double center instrument when shooting vertical

Superintendent & Surveyor Communication

- Have clear expectations of scope of work
- Review as-built information for work in place on regular basis with project Superintendent
- Understand Project Schedule as it relates to layout needs
- Review safety needs to complete layout work
- Have pre-construction meeting to discuss steps and procedures to compensate for environmental working conditions

Multi Story Structure Types

- Structural Steel with Composite Floors
 - Common for High Rise Office Structure
 - Concrete or Braced Core (typical)
- Post Tension or Structural Concrete Structures
 - Common for High Rise Housing or Parking Ramps
 - Concrete Core (typical)
- Pre-Cast Plank with Masonry Bearing/ Party Walls
 - Common for Low Rise Housing/ Hotels
 - Masonry Core (typical)
- Pre-Cast Concrete Structures
 - Common for Low and Mid Rise Parking
 - Pre-Cast Core (typical)

Layout Experience Example

AT&T Tower Class A Office Building Minneapolis, MN

Building Facts

- ❑ 33 Floors
- ❑ 462 Feet Tall
- ❑ 170'x140' Footprint
- ❑ 675,000 Sq Feet
- ❑ 3 Level Below Grade Post Tensioned Parking Ramp
- ❑ Structural Concrete 1st Floor
- ❑ Concrete Core – Self Jacking System
- ❑ Structural Steel Frame- Composite Deck Floors
- ❑ 14 Elevators
- ❑ 4 Story Atrium
- ❑ Last building constructed on Block
- ❑ Curtain Wall Exterior Skin – Granite Veneer at Bottom 3 Floors



How We Did It

- Concrete Core
 - Self Jacking Core System
 - Core was constructed minimum of 6 floors ahead of steel erection
 - Established points on core interior at ground level and used Zenith Nadir to plumb up core. We moved up our control points two times using overhead protection with trap doors for shooting thru
 - We brought up elevations using a steel chain from core footing to each floor. We used a tensioning device, temperature chart, and the engineers creep-shrink table
 - We verified elevations at the lowest level of the core and at all of the structural building columns on a regular basis to check for settlement
- Steel Structure
 - Iron workers surveyor plumbed structure with exterior offsets using a Theodolite
 - We double checked them periodically using same method. We also verified slab edge location and elevation by using control from the core

How We Did It (continued)

- Structural Steel (continued)
 - We shot top elevations of the columns every 4 floors using control on the core with an automatic level. We supplied this information to the fabricator and the structural engineer to make adjustments in column length
 - Control brought up on the core were used to lay out knife plates welded to embed plates for beam connections
 - We verified curtain wall anchor locations fabricated the slab edge prior to concrete pours. These anchors had to be located very accurately both horizontally and vertically to enable efficient curtain wall installation

How We Did It (continued)

- Building Horizontal Control
 - Grid lines established on 1st floor using outside layout & verified with concrete core layout
 - Three points were established on 1st floor. One on east/west line, One on north/south line, and 1 at the intersection of both lines
 - Prior to concrete placement three sleeves were placed at control point locations at each floor up the entire building
 - Using the Zenith Nadir each point was shot up to the floors through the three sleeve holes using acrylic targets. Always making sure to double center the instrument
 - Each point was verified to match the floor below using a plumb bob in a pipe. The pipe helps with wind. We also turned a 90 on the three new points with the Theodolite to verify square
 - The grid lines were then marked, chalked, and scribed into the floor
 - These control lines along with the elevations on the core were then used by everyone for their work.

Service Procurement Strategies In-house vs. 3rd Party

- Self Performing Construction Layout
 - Do we have In-house expertise?
 - Are these resources available?
 - Do we have proper equipment?
 - Is other work available to fill work schedule?

- Subcontracting Construction Layout
 - Availability of qualified subcontractors?
 - Will subcontractor be able to perform all layout duties? (union issues)?
 - Am I confident in subcontractor's ability to perform timely and accurately? (references or past experience)?
 - Does subcontractor cost fit budget?
 - Proximity of subcontractor to project site
 - Professional Insurance Considerations
 - Survey Lead tenure/ building layout experience

Measurement of Performance

- Has accuracy of control been maintained throughout project?
- Has survey team been timely with control enabling other contractors to be efficient?
- Has survey team worked safely?
- Has survey team communicated regularly with Superintendent?
- Has survey team performed all tasks given?
- Was survey team efficient with their time?
- Consistency of lead surveyor?
- Responsiveness and flexibility to fit scheduling needs?

Questions?

Thank You!