Figure 3-36. The final site organization and layout for the site drawn over the Google Earth image.

Figure 3-37. A typical site organization and layout drawn over the Google Earth image.
CHAPTER 3

CONCLUSION

Planning the organization and layout of a building site is a key task that has to be carried out by the construction contractor. It is essential to get this right the first time as it can impact the time it takes to complete the work, the amount of money a contractor spends, the quality of the work, pedestrian and traffic access, as well as the storage of materials and the plant and the safety, health, and working conditions of workers. The recent advances in web-based technologies such as Google Earth, Google Maps, and Google Street Finder offer construction contractors new ways to approach the planning of the site organization and layout from their offices, provided they have access to a computer and an Internet connection. The number of new software packages and web-based applications is growing all the time. BIM, Autodesk’s Navisworks, and point cloud recognition all have a role to play in future construction site organization and layout.

QUESTIONS, PROBLEMS, AND EXERCISES

1. Compare and contrast the impact on the site setup for a construction site in a brown field site location with that in a green field site location.

2. What are the key areas that a CM should consider when planning the site organization and layout for the construction project?

3. Can we ever have enough offices and laydown space for efficient construction to take place? Discuss.

4. Google Earth can be a useful tool at a manager’s disposal while he is planning his site organization and layout for the construction project. Pick a local site (existing, greenfield or brownfield) in your area and show how this tool can be used for planning the site organization and layout.
SECTION II
THE SITE AND FIELD ENGINEERING ISSUES

A number of construction-oriented publications include many of the site management issues mentioned in other sections of this book. However, experience teaches that technical engineering matters must also be considered if truly comprehensive site planning shall be performed.

It is not intended that the contents of this section should suffice for deeper, formal coursework in the subjects. Enough information is presented that prospective superintendents should understand the activities, which might comprise common field engineering, soil retention and stabilization, and drainage, as well as the need to plan for these engineering activities. They should also take away a good idea of the services and assets that must be timely subcontracted or requisitioned to accomplish these tasks for a typical building construction project. Simply stated, a competent superintendent must have a sufficient technical background in order to properly plan construction activities on his or her site.
CHAPTER 4
BUILDING LAYOUT

Douglas P. Keith

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INTRODUCTION
This chapter assumes that the reader has learned basic surveying skills and calculation processes. Therefore, the focus of this chapter is on concepts, principles, and practices needed to successfully plan, place, and check the layout of building construction activities.

Project controls are horizontal and vertical planes that form a three-dimensional (3-D) network that directly relates ground dimensions and location to the building structure, bridge, or roadway design. This allows one to go directly to any location or point, because they are all tied together geometrically and in the case of coordinates, mathematically.

Control points can be arranged in various ways by methods as simple as batter boards to known coordinates. The primary control should have no tolerance for error as they should be located as accurately as the methods and equipment will allow.

Regardless what method of control is to be employed on your construction site, there is one common theme that should be the most important aspect of any layout—planning. All aspects of any layout should be well thought out. Make planning a habit and your layout will occur with fewer mistakes and errors. The following paragraphs describe ways to help with your planning.

PLANNING

Visualize the project: Familiarize yourself with the plans and specifications. Picture in your mind what the structure will look like. Think about critical lines that are the core of the structure. Reading, studying, and learning the plans and specifications are the first steps toward visualization.

Sketch the structure: As you start visualizing the project, begin to draw rough sketches of how you see the structure and how the control will accommodate the layout process. This process will help reduce mistakes and errors in designing the control for the structure layout.

Schedule the layout: Look at and study the activity schedule to get a feel for the sequence of construction events. Using the schedule will enable you to plan your work ahead for times when layout will be intensive. Plan to establish the control well in advance of critical layout times so the control will be available when needed.
Consult: Consulting with your supervisor or other experienced members of the staff is a positive attribute. Ask for their layout preferences and suggestions for improvement to your plan. The better field engineers will check with all available resources prior to layout.

Visit sites: Prior to construction activities, visit the jobsite and walk around to discover what exists in the surroundings. Be aware of factors that may affect layout, including trees, hills, existing structures, utility markers, or any other issues that could inhibit layout. Take pictures of the entire area as a method of recording the terrain and any obstructions. Search for property corners to see if they appear to have been disturbed. Look for the benchmark that was used in the design phase of the project. Find areas that will offer good protection for control monuments that will be out of the way of construction activities.

Plan the offsets: Come up with a plan to establish offsets. Two to four feet inside column lines are common. Vertical datum could be two to four feet above finished elevations for floors. Whatever offset is decided upon as a project standard, communicate this information to all project personnel.

Be flexible: Not all measurements or actual construction will come out as planned. Unforeseen events, errors, issues, and conditions may cause adjustments to be made to the actual construction or layout of adjacent work. All changes and adjustments need to be approved by the superintendent and subcontractors in the field.

PROJECT CONTROL

The most important layout procedure to be performed during the construction process is establishing the project control to be used for the work. The precision and care used to establish project control must be exact and the tolerance for error as close to zero as possible.

As mentioned before, planning is the key element to establishing the project control. When planning the control, the field engineer must consider the type of project that is being built. Is there more than one building? Is it a bridge or a wastewater treatment plant? Identify the type of project and determine the best method for establishing the project control by reviewing the plans and specifications and visiting the site.

The Site

Factors that need to be addressed regarding the site are:

1. Is the site in an urban or rural area?
2. Urban areas may be restrictive for space to allow the control to be protected from construction activities due to congestion. Rural areas normally provide more space for the control to be out of the way of construction activities.
3. Terrain must be considered. Is the terrain steep or in a flood plain? These conditions could present difficulties for control protection and usability.
4. Check some of the site dimensions on the plans to see if they agree with the actual conditions on the ground. Does the project actually fit the site? Do the property corners measure the same as indicated on the plans? If not, call the professional land surveyor to compare the results of what you have measured versus the plan.
dimensions. Remember, unless you are a legally licensed land surveyor for the state you are working in, you cannot move, reestablish, or alter any property markers.

**Selection of the Layout Method**

With a thorough understanding of the scope of work, site visitation, and review of the contract documents, the method of layout can be determined. Some consideration should be given to the surveying equipment that is available, the competency of the layout crew, the preference of the superintendent, and the competence of the crafts who will be using your staking information. Several layout methods will be discussed, such as radial, intersection, baseline, and 3/4/5, as well as the pros and cons of each method.

**Designing the Control**

Once the method is determined, the control can be designed to fit the needs of the project. The control is going to be used through the entire time span of the project. Ask questions such as:

- What control lines are needed for form work?
- Where will the haul road be located?
- Where will the job trailers be located?
- Where is the laydown area going to be located?
- What control will be needed after the frame is erected?
- Are there any traffic obstacles?
- As the job progresses, there will be changes to the structure. Can I still see my targets?
- Target stability from demolition or frost heave?
- Will there be construction interference, such as form work, scaffolding, cranes, and temporary structures?
- Is safety always a concern during the entire life of the project?

Always make sure that you prepare for working through and around obstructions and plan the control so that each monument has at least two other monuments in view.

**Monumentation**

Put some thought into the types of monuments that will be used. They should be permanent, solid, identifiable, well marked, referenced, and protected. There are two types of control: horizontal and vertical. The control may be either horizontal or vertical, or they may be combined.

*Horizontal Control*

Horizontal control has a hierarchy that includes primary, secondary, and working stages. Primary means permanent and is generally located at the outer limits of the construction area or maybe off-site to provide the most protection. It must last throughout the life of the project. The tolerance for the primary should be as close as your equipment will allow. Many contractors will often hire a professional surveyor to establish the primary control as their equipment is usually of higher quality than what is typically owned by the construction
company. Additionally, the monumentation for the primary control should be constructed with concrete and placed to a depth that is below the frost line or, if in expansive soil, placed as deep as the bedrock and with a slip shield around the monument pin that will protect it from vertical movement of expanding and shrinking soil conditions. A common practice is to cast a set of tripod legs into the concrete monument when the setup of an instrument is required on a daily basis. This could be expensive to build, but when many projects cost several hundred million dollars to build, the expenditure of $10,000 for primary control could be warranted.

Secondary means semipermanent and is usually placed inside the construction limits; therefore, a lot of planning is required for the placement of the secondary control. It may be constructed in the form of batter boards, driven rebar pins, wooden stakes, or even concrete monuments. If existing concrete or pavements are nearby, then scribe “X’s” on them. Secondary control should be approximately within 100 ft of the construction activity. The life expectancy of secondary control should be for a few months and measured to less than 0.01 ft for tolerance.

Working control is very temporary. It may be nothing more than chalk lines and is usually covered up with the construction activity immediately. It should be established as close to the construction as needed and have a tolerance of one-half of that of the construction tolerance for what is to be built. For example, if you are placing grade stakes for earthwork, the typical tolerance for placing earth is to the nearest 0.10 ft; therefore, the tolerance for the grade stakes should be to 0.05 ft.

Control must have no mistakes. While establishing primary control, repeat all measurements at least three times to ensure the closest possible true measurement. Change your procedure or equipment in your measurements. This will help avoid the same mistakes that might have occurred the first time.

![Figure 4-1. Typical control layout from primary to secondary control.](image)
Develop a plan for establishing benchmarks on the construction site. Most existing benchmarks (BMs) that were used for the design process are located some distance from the site and require the need for temporary benchmarks (TBMs) for construction. When establishing the TBM network for the site, try to establish the TBMs 200 to 300 ft apart and in view of other TBMs. Most important is to start at an existing known BM and run a level loop through the site and close the loop to another known BM. If there is a discrepancy between the known BMs, contact the designer to establish which BM is to be used for the datum. TBMs should be established on solid items such as fire hydrants, existing concrete, anchor bolts, rebar pins driven into the ground, or spikes in power poles. They should be recorded in the field book and described completely as to where and what the TBM is with the elevation. While setting any TBM, be sure to always close the level loop to a known BM. If you do not close the loop, then you run the risk of building something at the wrong elevation, and it will have to be removed and replaced at the expense of the construction company!

**Preservation of Points**

To preserve the horizontal and vertical control, one must provide protection. This may be in the form of concrete barriers that surround the point to wooden lath with flagging. As soon as practical, always transfer the horizontal and vertical control to the structure that you are building. After the first concrete pour, at grade, transfer the vertical control to the slab, then establish the horizontal lines to the slab as this will lock down where the rest of the structure is to be built.

Planning and good communication is the key to a well-functioning and profitable construction project.
People who perform layout for construction projects may have their own method and procedures that they employ. However, the following rules, which have evolved over the years, have proved to be successful.

**Layout from Critical to Noncritical Dimensions**
In a building or bridge, there are certain lines that are considered critical to the overall layout of the structure. On a bridge, the road pavement must meet the bridge at both ends in the horizontal and vertical planes. In a tall building, the elevator shafts must be plumb and square and the rest of the building must be built around the elevator shaft. In both examples, the critical lines are usually easy to identify. Once the critical lines are established, the work can proceed to noncritical lines. Noncritical lines must also be established with precision, but other lines are not dependent on them.

**Begin in the Middle and Work Outward**
For many types of structures, it is a good practice to establish the center line control of the structure then work toward the edges of the structure. If there are any minor errors in the center line layout, they will be distributed to opposite edges, therefore making the error even smaller, and have a smaller effect on the completed layout.

**Avoid Cumulative Errors**
When laying out consecutive distances (e.g., 25-ft column spacing for a building), it is not a good practice to make the first 25-ft measurement then move the zero end of the chain to the first point and measure another 25-ft space. Instead, lay out the entire chain and hold zero at the starting point then mark 25, 50, 75, and 100 ft. Moving the zero end of the chain for each measurement runs the risk of introducing error for the spacing of sequential columns.

**Use Long Backsights and Short Foresights**
A backsight has a known elevation, much like a benchmark, while a foresight does not. The simple concept of using long backsights and short foresights during the layout process has the effect of reducing sighting or instrumental errors by nearly the ratio of the two distances. Therefore, this principle should always be employed in layout activities.

**Surround the Construction Site with Control**
Surround the construction site with control outside the construction limits. If this is done, then the long backsight–short foresight concept will usually be available and will help reduce instrumental and sighting errors.

**Work to Practical Tolerances**
Some specifications may list tolerances that are expected to be followed. However, if the tolerances are not stated in the contract documents, then the superintendent should direct that the standard tolerances for construction activities will be followed. If in doubt of the tolerance to use, ask higher authority so that no time is wasted trying to lay out points to a tolerance that is not necessary. A good rule of thumb would be “one-half of what follows.” This means that