Design Considerations for School Site Plans

by

Ida Buckles, PE
I. Introduction

The purpose of this course is to present some basic design considerations in the preparation of school site plans. Depending on the size and grade levels of the proposed school, certain design elements are more involved than others.

While school site plans share the same basic components as any other site plan, that is, a layout plan, grading plan, storm drainage, water, sewer and landscaping; school site plans have unique characteristics that will almost certainly require collaboration and consultation with various specialists as well as possibly lengthy coordination with school committees. This course focuses primarily on those unique characteristics and briefly touches on the typical site components.

One of these characteristics is vehicle circulation. The emphasis here is on school bus and private vehicle passenger loading and unloading areas as well as pedestrian pathways.

Another characteristic of school site plans is the need for athletic facilities. Although the civil design aspects of these are straightforward, the related equipment and amenities are not a typical civil land development function but still need to be incorporated or provided for in the plan.

For school site designs, an architect is usually the lead professional and handles all of the programmatic planning issues; such as expected number of students, staff, buses and private vehicles, desired functionality of the facility, coordination with school committees, and development of conceptual site and building plans. Often the architect will assemble a team of civil, structural, electrical and mechanical engineers and landscape architects to provide a set of construction plans or drawings for the school district and reviewing authorities.

It should be noted that accompanying the site plan or construction plan is a set of construction specifications covering among other things, minimum performance and material standards and testing methods. The Construction Specification Institute is the usual source for these specifications; however, many municipalities require their own specifications to be used for certain elements. In addition, schools on military facilities utilize federal specifications as their standard.
II. Layout Considerations
A. Vehicle queuing /stacking

We all have seen at one time or another or participated in the twice daily mass convergence of cars, vans and buses in the vicinity of schools. According to the “2015 Fact Book” published by School Bus Fleet magazine, nearly 25 million students (grades K-12) in the United States were transported by bus on a daily basis for the 2012-13 school year. Additionally, a 2017 Washington State Department of Transportation study of kindergarten through 8th grade students, stated that approximately 38% of students rode in a private vehicle, 42% rode the bus and 17% walked. Furthermore, a Safe Routes to School National Partnership article stated that in 1969, 12 percent of U.S. students were driven to school and by 2009, 45% of students were driven to school in the family vehicle. Clearly, designers have the opportunity to help alleviate this increased traffic congestion.

In order to determine the minimum length of the vehicle queuing lanes around the school, the designer must coordinate with school district officials in terms of determining the number, types of vehicles expected and peak congested periods. If the project is set up wherein the architect is the lead then most likely the architect will provide this data to the design team via the school program and planning documents.

If the school site plan is for the replacement of an existing school then there should be plenty of data to help determine the number of vehicles picking up and dropping off students; as well as the number of students who drive themselves. If data is unavailable, the engineer may need to participate in physical observations at peak hours. The number of buses is normally a fixed amount for a replacement school so that number should be readily obtained. If, on the other hand, the site plan is for a new school due to population growth then surveys may have been or need to be sent to households in the designated service area asking how students will be transported to and from school. Larger school districts have a plethora of guidance documents, studies and data from which to extract information.

Once the expected number of buses and private vehicles has been determined one can estimate the minimum needed stacking lane length by multiplying the length of the vehicle by the number of expected vehicles. For example, if 5 buses were queued up to pick up students, each bus at 45’ in length, then one would need a minimum of a 225’ long, off-street stacking lane; and this does not include maneuvering space. As for
cars, naturally there would be many more cars and vans than buses. So, say for example, 50 cars would be expected to be waiting, each at 20’ long; then 1,000’ would be needed at a minimum. There are cases where 2 lanes would be needed in order to avoid vehicles spilling out onto city streets; this is where a skilled traffic coordinator will help avoid conflicts. Thus, if one is fortunate enough to have a large site to work with then long off-street queuing lanes are very desirable. The designer may need to inquire if the school has their own design standards for pick up/drop off areas. If possible, siting the school building as far back as is practicable will help lengthen the queuing lane. The pick up/drop off lanes need one lane for loading and one for passing. A common lane width is 12’.

It should be noted here that the success and safety of the loading/unloading process depends heavily on enforcement of certain rules; such as no prolonged stopping in the passenger loading zone; similar to airport situations. Pavement markings and signage are unfortunately not adequate to keep the loading process moving. Traffic control personnel, whose duties are assuredly spelled out in the school district guidelines, will help in this effort.

B. Circulation
Tied in with the pick up/drop off areas is the vehicle circulation pattern as a whole. For safety and smoother operation it is important for the bus loading areas to be separate from the private vehicle loading area. It is not safe for pedestrians to walk between buses to reach awaiting cars. Thus, the ideal situation would be to have completely separate entrances, driveways and loading areas; one for buses and one for private vehicles. A simplified layout of this concept is shown in Figure 1.
Figure 1. Example of a vehicle circulation pattern at a school.
Figure 2 shows a picture of a high school private vehicle pick up/drop off zone. There are two lanes; the right lane is for loading or unloading and the left is for bypassing. Passengers exit the passenger side on the right onto the sidewalk. During loading and unloading, a crossing guard manages vehicle and pedestrian traffic.

For all vehicles, including buses, fire trucks, maintenance and delivery trucks; an adequate turning radius must be provided. A turning radius is the smallest radius within which a vehicle can turn or put another way; the radius of the arc formed by the turning path of the front outside tire of the vehicle. Some municipal codes or design standards may use 50’ or 60’ as a minimum. A common entrance radius for cars is 25’. Figure 3 show a simplified diagram of a vehicle turning radius.
In terms of the turning radius, it is important to take into account not just the wheels (as in curb-to-curb radius) but the body overhang, bumpers, mirrors and bus crossing arms (as in wall-to-wall radius) in case there are ground structures or above ground hanging objects near the bus path.

One informative source of school bus dimensional information is the “National School Transportation Specifications & Procedures” which states that a Type C bus (shown in Figure 4) shall not exceed 102” (8.5’) in width, excluding accessories and shall not exceed 45’ in length, excluding accessories. It also states that a chassis with a wheelbase of 264 inches or less shall have a right and left turning radius of not more than 42½ feet, curb-to-curb measurement. A chassis with a wheelbase of 265 inches or more shall have a right and left turning radius of not more than 44½ feet, curb-to-curb measurement. It further notes, “. . . all school bus roads entering into or exiting from main arteries should have a 50- to 100-foot radius turn on the inner edge of pavement. Within the school site, roads should have at least a 60-foot radius on the inner edge of pavement on all curves.
At least a 50-foot tangent section should be provided between reverse curves. A School Bus Fleet magazine article stated that about 70 percent of school buses sold in 2014 were Type C.

Federal and State Departments of Transportation also have turning radius information for many types of vehicles. Furthermore, computer aided design (CAD) software have truck turning simulators which draw the moving path of vehicles; both the tires and the body. This is helpful in space constrained areas.

Some other design considerations for pick up/drop off vehicle circulation are:
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- Private vehicles including buses should follow a counterclockwise movement with passengers exiting from the passenger side on the right.
- Crosswalks should be placed at strategic locations to encourage and help enforce crossing at safe locations.
- Bus entry and exit routes should be designed so that no backing up or backward movement is required.
- Proper signage such as “Buses Only” at each bus loading zone entrance.
- Access roads for maintenance, delivery and special events need to be incorporated into the plan in such a way as to not conflict with student pick up/drop off.
- Reduce pedestrian conflicts between pick up/drop off procedures and parking maneuvers at student and staff parking lots.

C. Athletic areas
Another unique aspect of school site design is the provision of athletic areas. These might consist of football, soccer or baseball fields, tennis courts, bleachers, concession buildings, outlying restroom facilities or outdoor swimming pools. Due to the specialized nature of these types of amenities, the civil engineer will likely consult with design professionals experienced in the various specialties. Some landscape architects specialize in these designs as well. So while the engineer may not be involved in the specific amenity details, he or she will still need to provide on the site plan; the required layout, dimensioning, grading and drainage features for these types of facilities. Some interesting and informative resources that the engineer may want to examine are provided by the following organizations:

- Sports Turf Managers Association (STMA),
- National Federation of State High School Associations (NFHS),
- American Sports Builders Association
- United States Tennis Association, Inc.,
- United States Tennis Court and Track Builders Association
- American Society of Testing and Materials

By familiarizing himself or herself with some of these resources, the engineer will be better prepared to design a suitable infrastructure for these components.
III. Grading considerations

Due to accessibility requirements and also the athletic activities that go on at school, school sites should, generally speaking, be relatively flat or mildly sloping. If this is not feasible, potential ADA (Americans with Disabilities Act) accessible pathways should be examined early in the design process. The ADA maximum slope for walking surfaces is 1:20 (5%); for ramps the maximum slope is 1:12 (8.33%) with a maximum cross slope of 1:48 (2.08%). The maximum rise for any ramp run is 30” which calculates out to approximately a 30’ maximum ramp length. Further details may be obtained from the “2010 ADA Standards for Accessible Design” published by the U.S. Department of Justice.

The sports fields have their own industry guided design specifications in terms of slope. As was previously mentioned in Section 2C, various organizations publish design guidelines for the various sports fields. A sampling of various slope ranges is listed below:

- Soccer fields: 1% crowned from longitudinal center
- Tennis courts: 0.28% to 0.83% or more depending on type of court; clay, fast-dry, hard; sloped in one plane only, not crowned
- Baseball fields: 1% in all directions from the center pitcher’s mound outward
- Running tracks: 2% maximum laterally, 0.1% in running direction
- Football fields: 1% to 1.9% crowned from longitudinal center

Note that the above listed slopes are for general information only and as was stated previously, consultants who specialize in sports field design will be the best source for this type of information. School officials must needs participate in the final design as well. Nonetheless, these slopes emphasize the advantage of selecting mildly sloping sites, in terms of lower grading costs.

Other areas of school sites such as parking lots and open space would follow standard engineering practice in terms of grading and are covered in other courses available from SunCam.

IV. Drainage considerations

Drainage design for schools entails the same systems as other types of development. Surface drainage (swales, ditches, channels) and subsurface drainage (pipes); as well as stormwater management (SWM) facilities will all likely be utilized in the design. An
attendant note here is that stormwater ponds should be fenced whether or not it is specifically spelled out in the local ordinance.

The sports fields discussed in the previous section need their own individual drainage systems in order to drain properly and maintain their unique surface features. Generally speaking, along with the appropriate stone base drainage layer, these would consist of perimeter underground drains, also called trench drains, drain tiles, French drains etc., which consist of perforated pipes set in gravel trenches. These drain pipes would either be connected into the main campus storm drain system leading to a SWM facility; or they could outfall to a suitable receiving channel if there are no toxic chemicals used on the fields. The stormwater permit will specify the required measures to be implemented. Manufactured trench drains with grate tops, as well as grate inlets and catch basins can also be used, providing their surfaces do not interfere with the sports activities and pedestrian traffic.

One issue concerning drainage ditches or grass swales that should be mentioned is that of maintenance. A grass swale with mild side slopes is much easier and faster to mow than a deep ditch. So, if a swale will provide the needed drainage it is preferable over a steep sided ditch or channel, from a maintenance standpoint.

Another aspect related to drainage is the particular location of soil borings. While there will be the usual soil sampling for the building, parking and road areas; additional sampling should be conducted at the proposed sports fields and the stormwater management areas. Some characteristics which may negatively impact the drainage and constructability of these areas are:

- High groundwater
- Clayey or expansive soils which shrink and swell
- Organic soils
- Previously placed fill dirt
- Debris dump sites
- Impermeable soils

A final point is that some schools may be designated as emergency shelters and therefore may require more stringent stormwater controls. The Federal Emergency Management Agency publication, “Design Guide for Improving School Safety in Earthquakes, Floods,
and High Winds” dated December 2010 and the American Society of Civil Engineers offer additional information.

V. Erosion control
Erosion control for schools is essentially the same as for any other construction plan in that the goal is to prevent sediment from leaving the site and eventually ending up in streams and rivers. The typical components utilized are: silt or sediment fences, straw bales, silt socks, diversion berms, sediment/silt traps and sediment basins, to name a few. (Terminology may vary from region to region.)

On smaller commercial sites, silt fence may be completely adequate but for a larger site like a school, silt traps will undoubtedly be necessary. Some localities only allow ¼ acre of drainage for every 100 feet of silt fence, for example. Thus, with some schools ranging from 20 to 30 acres in size, a sediment trap is a convenient option to control sediment. Sediment traps are limited in how much of a drainage area they can serve; 5 acres in some localities. Sediment traps, simply put, are roughly rectangular excavated pits designed to capture storm runoff and settle out sediment. An easy volume sizing rule-of-thumb is 3600 cubic feet per acre of disturbed area. This may differ in each locality.

VI. Water supply considerations
Naturally an adequate water supply will need to be provided to the school. Not only will the school and other outlying buildings need water but irrigation water will almost certainly be required. Assuming a public water supply, separate metering of the irrigation flow is common. Additionally a separate fire line is normally required.

Although the mechanical engineer will design the interior water line size needed for the building, continuation of this size to the main may not necessarily supply adequate pressure due to head (pressure) losses. The engineer will need to confirm if the supply line should be increased. The service line for a school may be very long or the school site may be considerably higher than the main; causing excessive head losses. Some local utility authorities prefer to continually update their water distribution system modeling software by inputting new facility data into the model to determine if the proposed service size is adequate or not.

A thumbnail procedure for sizing the water supply line to the building is; determine the design flow, the available pressure, the required pressure, the length of the service line,
and the elevations of both the main tie in point and the school. The design flow rate and required pressure may be obtained from the mechanical engineer or fixture values tables; the available pressure may be obtained from the utility’s water model or hydrant testing; the service line length from the site plan; and elevations from the existing survey. After calculating all of the head losses due to elevation, pipe friction, valves, fittings and other losses one may determine if the resultant pressure meets the minimum required pressure. Water modeling software is available for these calculations. One free version is EPANET, available from the U.S. Environmental Protection Agency. Meter sizing is usually dictated by the local authority.

VII. Sanitary sewer considerations
Similar to the water line sizing, the mechanical engineer will design the size of the sewer line(s) coming out of the building. It is the civil engineer’s task to size the line going from the building to the sewer main; it may be referred to as a service lateral. Normally, this involves calculating the peak flow from the average daily flow which is obtained from design tables. Then a pipe size and slope are selected and using the Manning equation the velocity is checked. Other methods are available. A common minimum required velocity is 2 feet per second (fps) when flowing full. The calculations may yield a smaller size than what is allowed per the local design standards; in which case the code required size should be selected. Steeper slopes, in the 9% or 10% range are discouraged along with high velocities; say for example, 15 fps. Consult the utility’s design manual for guidance.

Cleanouts should be provided at each change in direction with distance between cleanouts usually limited to 100’.

VIII. Landscaping and special amenities
A. Landscaping
The local municipal codes will determine landscape requirements. There will likely be “street” trees required along the frontage and canopy and/or understory trees in parking and open space areas; in addition to shrubs and ground cover. Again, terminology varies depending on the locality. The landscape architect is tasked with ensuring that his or her planting scheme satisfies the local requirements.

Likewise, the stormwater management areas have their own unique set of landscaping requirements which are usually spelled out in the state or local stormwater management manual. For example, a wet detention pond requires a shallow water emergent plant in a
specific zone of the pond. Similarly, bioretention basins also have very specific planting requirements.

Lastly, the sports fields require specialized turfs, whether natural or artificial and this too is quite a science unto itself. Resources for this subject were previously listed in section 2C.

B. Special amenities
There are some items that may need to be specially detailed on the site plan such as:

- Bike racks
- Playground equipment
- Climbing devices
- Swings
- Slides
- Batting cages
- Benches or outdoor seating areas
- Concession building accessories
- Recycling areas and containers
- Decorative lighting
- Special entrance features not handled by the architect.
- Vehicle maintenance areas
- Scoreboards

IX. Conclusion
While school site design encompasses the same basic elements as commercial and residential subdivision design; the need for sports facilities and the intermittent confluence of numerous vehicles and pedestrians require that engineers become knowledgeable about these unique aspects of school site design. Gaining this knowledge will, in due course, benefit the school as well as the surrounding community.
References


