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Stadium
This book is dedicated to my wife, without whose support I could never have accomplished this, and to the rest of my family, for whom I work to make proud.
I would like to acknowledge those people who have assisted and guided me throughout this process.

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- Brad Bittermann
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The project presented here is an NCAA Division I capacity football stadium located on the campus of James Madison University in Harrisonburg, Virginia.

This stadium is a vehicle for exploring and expressing my ideas about the role of structure in architecture, and about an architect's realm of control in a building project. The typology of a stadium allows for a limited number of functional requirements while, at the same time, allowing for, if not demanding, a creative structural solution.

Abstract
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James Madison University sits in the Shenandoah Valley in Harrisonburg, Virginia. The campus is divided by I-81, with the older section to the north and the newer section to the south.

The older part of campus contains the original quadrangle which is surrounded by academic and dormitory buildings which are constructed of the university’s trademark bluestone. Also on the northern campus is the majority of the campus’ other dormitories, academic and administrative buildings, and dining facilities, as well as the old fieldhouse and the current football stadium.

The newer part of campus houses a few residence halls, academic buildings, and eating facilities. However, the predominant features of this area of campus are the recreational facilities. The Convocation Center (for basketball games, indoor graduation ceremonies, and trade shows), the University Recreation Building (the student fitness center), the soccer stadium, and the arboretum take up most of the space on this southern side of campus.
Bridgeforth Stadium, the current football facility for James Madison University, was designed by D'Earcy Davis Jr. & Associates and was built in 1975. It sits on the northern section of campus with its long axis oriented north-south. It has two seating sections, one along each long side of the field. A large scoreboard stands behind the north end zone, and a set of temporary metal bleachers for the marching band is located behind the south end zone. At the top of the eastern seating section stands the press box. The space underneath the seats is enclosed, and houses the football offices, locker rooms, bathrooms, and is home to the university's military science department.

To date, the stadium has sufficiently served its functions. Thanks to football, lacrosse, and intramural games, track and field meets, students jogging on the track, and graduation ceremonies, there is hardly a day when the stadium goes unused. The facilities are in good condition and the grounds are meticulously maintained. There are enough seats to meet the demand for tickets.

However, the stadium has some shortcomings, both functionally and architecturally. First, it has a capacity of 12,500, which falls well short of the 30,000 minimum for a NCAA Division I-A football stadium. The football program is the university's only athletic program which does not enjoy Division I-A status, and would not ever be allowed to become a Division I-A program without a bigger stadium.

Second, the field is made of artificial turf, which is alleged by many to cause more injury to players, and is looked down upon by football purists.

Lastly, and most architecturally, the stadium lacks a sense of enclosure. Of course it is physically enclosed, by the seating areas on the two long sides and by chain link fences on the short ends, but visually the stadium has no containment. The result is a loss of intimacy between the fans and players. Furthermore, any architectural presence the stadium has stops at its walls, and in the case of the chain link fences, does not even make it to the physical boundary.
The Influence of Technology

Throughout time, technological advances have continually changed the face of architecture. New and refined materials have achieved higher performances. We can support heavier loads, span incredible distances, and scrape the sky. The development of materials such as concrete and steel, in combination with the power of cranes and trucks, have expanded the architect’s palette tremendously. Structures such as the Eiffel Tower, the Brooklyn Bridge, the Hoover Dam, and the Petronas Towers all stand as a testament to the advances made in technology.

However, while technology has undoubtedly contributed greatly, it has created uncertainty in architecture. Increasingly, the role of the architect in our society is challenged. When corporations had limited resources in the form of paper files, it was critical that all the employees were in one place to share them. At the same time, the price of land demanded that an owner get as much use possible out of that land. Constructing skyscrapers was the natural response. Computers have virtually destroyed the need to have all the workers in the same country, let alone the same building. Libraries suffer a similar predicament. With a wealth of information a mouse click away, the need for a building to house books loses its utilitarian importance. Some banks actually discourage their customers with fees for coming to the building to do business that can be done at the ATM or over the phone.

Similarly, stadiums cannot avoid the questioning of their existence. Before radio and television, the only way to experience was to go to the stadium. Now, going to a stadium must provide enough positive qualities to make up for the comforts visitors lose by leaving home. Going to a stadium must provide something to pry sports fans away from their big screen televisions and out of their recliners, and leave their food and drink in their climate controlled residences. One could begin to question if it would not suffice to simply have a field with surrounded by television cameras, so that everyone could stay home and watch in comfort.
Despite the convenience and comfort of staying at home to watch a game, people continue to flock to stadiums much as they did over 2,500 years ago. As early as the eighth century B.C., the Greeks built stadiums to facilitate foot races. Soon, as more events attracted more spectators, countless more arenas, hippodromes, circuses, and stadiums were built, the most glorious example of which is, of course, the Roman Colosseum.

These glory days of stadiums ended as Christianity spread across Europe and people spent their architectural efforts on churches. Thanks in large part to the reestablishment of the Olympics in 1896, the age of the modern stadium began, as countries the world over built stadium complexes to house the Games. Meanwhile, people were hungry for other spectacles, and stadiums were erected for tennis, soccer, rugby, baseball, and football.

As the game of American Football developed throughout the second half of the 19th Century on the campuses of several colleges, the popularity with spectators grew. The games attracted not just the student population, but the surrounding communities too. Soon, there were so many onlookers that standing on the sidelines no longer sufficed, and permanent stadiums began to go up in the 1920s.

Early on, the only way for a team owner to make any money was to have a full house. Stadium design focused on fitting as many seats as possible with little thought to fan comfort, no thought to accessibility issues, not to mention architecture. Due to their sheer size and lower frequency of use as compared to basketball and baseball venues, football stadiums often receive little consideration when it comes to high quality finishes that might add to the overall quality of the design.

With the advent of televised sporting events, the influences on designs change. Suddenly, the money from owning a team came not from the ticket holders, rather from the television revenues, and the stadium-going fan was secondary. As a result, stadiums were designed as platforms for television broadcasts, and the fans were thought of even less. The lighting needs for a good television broadcast do not necessarily equal lighting needs for good stadium viewing. That is not to say that achieving proper lighting for both the television and stadium viewing is impossible, but the priority was certainly in favor of the cameras.

Since the advent of free agency, team owners once again look to the fans for that extra revenue needed to keep a franchise afloat. This does not mean a return of trying to pack the stadium full of seats. Rather, attention is being paid to fan comfort in terms of seat size, number of seats in a row, number of restrooms, sight lines, amenities and so on. The introduction of luxury club boxes bring a tremendous amount of revenue from corporations and, in the college realm, loyal alumni.
A stadium is first and foremost the staging ground for spectacles for masses of people. However, this utilitarian perspective is limited and it belies the bigger implications of a stadium’s effects on the individual visitor and on the community it serves. The influence of a stadium is tremendous in its immediate surroundings, and, in some cases, can be felt around the world.

Having set a historical context to the stadium building type and seeing that it has huge ramifications on its environment, it is critical to determine the reasons for visiting a stadium versus watching a game from home. More specifically, it is critical to determine the reasons over which the architect has control. Clearly, having a winning team draws a crowd, but there is more to it than that. Even the losingest teams have supporters. There must be more reasons to the experience of stadium-going than a winning team, and the architect must have some influence over some of these reasons.

Looking a little further at today’s stadium, it is clear that it is more than just a place for a sporting event. What was simply a game has become a Game Day, filled with activities that revolve around preparing for the game, watching the game, and celebrating a win or mourning a loss. Stadiums can be thought of as a giant room for 10,000 to well over 100,000 people, where, for at least the duration of the game, most of these people are united with one another as they intensely cheer for the home team and viciously boo the visiting team. They become a community, if only temporarily, dressed in the same colors, waving the same flags, and chanting in unison. This experience begins even before the game.

For the players, it starts when they load on the bus and head off to the stadium, where they will put on their uniforms and prepare for the battle ahead.

For the student, it starts that morning when people paint their faces and bodies, and walk en masse to the stadium.

For the alumnus, it starts when he shines his class ring and drives the pick-up to the parking lot where he fires up the grill on the tailgate.

Everyone converges on the stadium in their respective costumes. Everyone knows what songs to sing, when to dance, and what routes to run.

In other words, the first thing that draws a crowd is the experiential, theatrical nature of gameday and for at least that day, everyone shares a bond through their participation in the show.

This is where the architect comes in.

Stadiums can be...

...a civilization’s greatest remnants.

...an attempt to demonstrate national strength and pride.

...an integral part of a city’s urban fabric.

...a nationally recognizable symbol of its institution.

...billboards.
THE LANDSCAPE

Given all the activities surrounding a game, it is appropriate to position and design the stadium to facilitate these various activities. Furthermore, the sheer size of a stadium automatically has a monstrous effect on the landscape in terms of its visibility, as well as the demands for space for the actual stadium and all the associated activities like parking. Therefore, the stadium's realm of influence does not stop at its physical boundaries. The design must define a new landscape for the surrounding area. As a defining element of a campus, the stadium's appearance, size, and location relative to other campus buildings are critical. The new landscape should integrate the spaces for activities outside the game. The new football stadium is to be the visual and symbolic center of this new side of campus. Due to the stadium's size (it holds approximately 32,000 people) and its location on top of a hill, it is the crowning piece on the new side and has a presence on the original part of campus, the interstate, and parts of the town of Harrisonburg. In addition, it is encompassed by a massive bluestone wall connecting it symbolically to the original section of the campus.

Aloha Stadium in Honolulu, Hawaii
The influence of this stadium ripples through its parking lot. The sections of parking describe concentric circles centered in the middle of the playing field.

Stadium in Turin, Italy
The elliptical shape of architects Hotter & Ossola's World Cup stadium radiates over the surrounding walkways and roads and into the parking lot.

1972 Olympic Stadium in Munich, Germany
This collaborative effort between Günther Behnisch, Frei Otto, and Fritz Leonhardt take the idea of the stadium as landscape to greater heights with an undulating roof system that creates a new symbolic landscape.
An exploration of forms through the use of folded paper models and sketches begins to answer the question of how a stadium should look. Although the studies focus on the overall configuration of seats, with little thought to the construction of the stadium, some of the models do imply a structural idea. While not every aspect of these studies exists in the final design, some of the major ideas about overall form and the pieces that make up the whole are present at the earliest stages of design.

These studies also reveal the fact that the form of all stadiums is derivative of the building's function, and not the other way around. In other words, stadiums look the way they do because they are designed for a specific task, namely, allowing a large group of people to simultaneously focus on the same event. Accordingly, it would not do to design a stadium with seats facing away from the field, or to have seating sections with no incline. The formal similarities that stadiums share stem from their functional requirements, and the variety of architectural quality found in stadiums is due, at least in part, to the resolution of these functional demands. This idea of finding the architecture through the expression of the utilitarian is also applied to design of the pieces which make up the stadium.

Similar to JMU's current stadium, these two-sided configurations (1, 2, 3) are unsatisfactory as they do not provide the feeling of a room. A good stadium should give a sense of containment that these corridor-like designs simply lack. This observation helped in deciding to design a stadium that is enclosed on at least three sides. The second and third images do imply a structural hierarchy. In the second image, the seating areas span between two primary arches. In the case of the third image, the seating areas span between two secondary members which, in turn, are suspended from primary supports. The final stadium design is not exactly the same, but the study presents a thought about a structural hierarchy even in the primary stages of design.

The concern here (4) is solely with an overall layout with no consideration for the manner in which it would be constructed. While it definitely achieves the sense of a room thanks to the complete enclosure by extremely sloped seating areas, the seating configuration leaves something to be desired. Seats along the long side of the field allow the viewers to watch the movement of the teams pushing their way up and down the field. Viewers from behind the end zones get to watch the blocking patterns develop. Those who have corner seats are caught in between and do not get to enjoy either of these aspects. This study helped in the realization that corner seats are the least desirable seats and that the number of corner seats should be reduced whenever possible.

The study (5) most closely resembles the final design of the stadium. It shows enclosure on all sides. In addition, it represents periodic primary structural members which hold up the spanning seating areas. All of these elements appear, albeit in different ways, in the end product.
This focuses on the structural hierarchy being the defining architectural quality of the stadium. It also stands as a reminder that functional elements, such as the lights, must be included, and should be made integral with the overall design.

Shown here is a stadium with the majority of the seating along the long sides of the field, one open end that forms the entrance, and no corner seating. It also demonstrates, once again, an attempt of creating an impressive structural solution.

This deals with the stadium's relationship to the topography. The horseshoe is nestled into the landscape in attempt to lower the visual impact on what is automatically a tremendous presence. This technique can be found in the final design.

This reflects an early thought of making a stadium comprised of series of smaller buildings. The question mark in the corner shows the long-standing desire to minimize corner seats.

This drawing shows a simple horseshoe plan. The important idea represented here is that of a repeated element that serves as the primary structure while giving the stadium a rhythm and a character.

This focuses on the structural hierarchy being the defining architectural quality of the stadium. It also stands as a reminder that functional elements, such as the lights, must be included, and should be made integral with the overall design.
The playing field is at grade and the seating area touches the ground. This creates an intimacy between the spectators and the players, but with respect to crowd control is inadequately handled.

This variation provides a separation between the spectators and the grade-level playing field with the use of a height change.

This represents a stadium in which the field is well below grade. This has the advantage of lowering the profile of the stadium.

The sketch demonstrates an idea that the seating section is the roof for an inhabitable space below. This idea can be seen in the final stadium design. The field sits below grade and the entry level separates the upper and lower seating sections.

A simple horseshoe plan. A entirely enclosed stadium No corner seats.
Clearly, one of the most important aspects of a stadium is its accessibility to the stadium visitor. To demonstrate the new stadium’s location in relation to the rest of the campus, a green circle represents the area in a one-mile radius from the center of the stadium. This distance was established as a reasonable distance to expect most people to be willing and able to walk to the stadium.

The green shaded areas represent the total available gameday parking on campus other than the parking directly next to the stadium. All of the available parking spaces fall within the one-mile radius of the stadium. In total, there are over 5,500 parking spaces. Assuming three people arrive in each vehicle, over half the stadium’s occupancy is taken care of.

Highlighted in blue are the Residence Halls. Most of them fall within a one-mile radius of the center of the stadium.

The red lines indicate the pedestrian paths from all the dormitories and parking lots to the stadium.
The red line highlights the most commonly used foot path to the stadium site. This West Side entrance in particular will see the most traffic as the connection from the old campus (highlighted below) is already developed thanks to the basketball arena which lies just northwest of the new stadium.

This tunnel runs under the highway to connect the old side of campus with the new.

Looking back after exiting the tunnel on the new side of campus.

Continuing up the path towards the Convocation Center

Footprints of JMU’s mascot, the Duke Dog, lead the way to the stadium.
The original buildings on campus are easily recognized by their bluestone walls. The perimeter wall surrounding the new stadium is also made of bluestone. The use of the bluestone wall connects the stadium to the original section of campus. At the same time, it establishes the stadium as the symbolic centerpiece of the new section of campus.

Inside the large perimeter wall stands another bluestone wall which separates the open space from the stadium. These three arches are smaller versions of the main entrance arch and mark the location where visitors surrender their tickets.
The design of the stadium and its surrounding site starts with the football field. The yard lines act as the generator for the placement of the structural members and for the layout of the parking area and adjoining open space.

The lower seating section holds 18,932 chairs. In an effort to create as intimate a stadium as possible, the seats in this lower deck completely enclose the field. The top of this section is actually at grade level. This move helps to lower the overall profile of the stadium. As is, it is massive and the structure reaches over 100 feet above grade. If the field were placed at grade level, the stadium would be over 160 feet tall.

The upper section holds 13,188 seats in a horseshoe configuration. The opening is located on the north end of the stadium, pointing to the original section of campus in an attempt to make a connection between the old and new. During the games, the sound of the roaring crowd would be directed towards campus as if out of a megaphone.

The space in between the upper deck seating sections is used for the system of ramps and elevators. The placement of the ramps in these spots helps to minimize undesirable corner seats, and they do not cut into the open space surrounding the stadium. The ramps also provide views of the field from certain points which means people seated in the upper deck can still watch the game when coming to or going from their seats.
A view of the foundation system which also serves as the wall for the area underneath the lower deck seating. This is the area in which the locker rooms, first aid room, kitchens, and the mechanical rooms are housed. The retaining wall utilizes a series of tiebacks which reveal their ends on the inside of the wall in an architectural expression of the work that the wall is performing.
The ramps, as with the stadium, are constructed from precast concrete pieces. They feature space where people can take a break from walking up the ramp without being in the main flow of traffic.
The green shaded area shows an open park-like area with room for grills and benches to encourage pregame festivities. The provision of this space is consistent with the position that a stadium does more than house a game, rather it is the centerpiece of a full day of activity. Furthermore, this space could be made available all year round as opposed to a mere six or seven Saturdays a year, providing the campus with another place for communal gathering which did not previously exist.

The grey areas point to the car region of the stadium's parking lot. The roads are narrow with many turns so as to keep the traffic speed down. These 540 parking spaces are premium spots and could be a good source of revenue for the university on gamedays.

The blue zone is the pedestrian region of the parking lot. The goal is to provide ample space in between rows for comfortable tailgating and to ensure that pedestrians never need enter the grey shaded zone to reach the stadium.
Tailgating has become an integral part of the gameday experience. At JMU’s new stadium, space is provided to facilitate comfortable, safe tailgating. During game day, as the parking lot fills, the pedestrian zone is enclosed by protective walls of parked vehicles providing an area safe from speeding cars. There is plenty of room for grills and coolers for tailgating, and there is no need for people to be where moving cars are. This zone is bordered on one side by a small bluestone wall.
This graphic delineates the optimum and maximum viewing distances for football. The region within the red circle is ideal. The next bigger region is the recommended maximum distance which is determined by describing a 150m arc from each of the corners. Beyond the outer ring, the ball would virtually disappear from view. This image demonstrates that the majority of the stadium’s seats fall within the recommended distance, and all of them fall within the maximum distance. This is consistent with the goal of providing the best gameday experience possible, which includes being able to clearly watch the game being played.

The blue lines represent lines of sight from various seats throughout the stadium. In the plan view, the lines outline a 60 degree field of vision from particular seats. This range approximates the range of a person’s vision looking straight ahead. In the section view, the blue lines demonstrate the ability of a person to see the field from various seats. The upper deck seating has a greater slope than the lower deck, to ensure that the people who sit the farthest away from the field still are able to see.
It used to be that construction crews were made up by groups of craftsmen. The architect was considered a master builder and had the ultimate control on a construction site. Now, construction crews could more precisely be called assembly crews.

The architect no longer plays the role of master builder and must rely on the assembly crews to realize his vision. Given the inconsistent and sometimes inferior workmanship in the construction industry, the architect takes a big risk by leaning too heavily on the builders.

If the designer cannot control the builders, then what is within the designer’s control?

The architect can control the building blocks.

The building should be viewed as a set of pieces, each one of which should be able to be critiqued on its own, but come together as a whole.

This idea lends itself particularly nicely to a project as large in scale as a stadium. The sheer size of the structure makes for an astronomically high cost, but the initial investment into sophisticated concrete forms could be recovered in such a project.
For the design of a Residence Hall at the University of St. Andrews, James Stirling chose a precast concrete panel system "because of a lack of skilled local building workers". Stirling designed a set of components that could be craned into position, leaving little opportunity for the builders to do anything but assemble the pieces.

Like pieces of a giant puzzle, the crane puts all the panels in their proper places.

The result is a building which derives its architecture from the clarity of its manufacture. The fact that the precast concrete panels are not hidden behind a facade indicates that Stirling looked to his prefabricated pieces for the architectural expression of the building.

James Stirling

Residence Hall for the University of St. Andrews
A Kit of Parts

The new stadium takes its architecture from the set of pieces that make up the whole. Here is the actual number of pieces that make up the major components of the stadium. All of the pieces are made of precast concrete and can be assembled on site.
The designs of Santiago Calatrava and Pier Luigi Nervi are influential in a couple of ways. For one thing, they both find their architecture through structural expression. The beauty of their work comes from the simple clear solutions to structural problems. Also, they both treat concrete with a lightness and sensitivity that only someone with a true understanding of the material can.
This model attempts to perform several functions at one time. Its front is sloped to hold seats. Underneath the seats there is circulation area, including platforms for walkways that could be part of a ramp system. The top of the model could contain an integrated lighting system for the field.

This model embodies the idea of having a primary structural member which fulfills several functions simultaneously. In this case, the cantilevered section of the model was to be the supports for seating sections which would provide a canopy for the seats below it. At the same time, this piece allows for passage through it below.

This model also takes its shape by providing support for seats and, at the same time, a space for circulation.

These two sketches, like some of the models search for an element that acts as the primary structure while creating circulation space and is visually distinctive.
This is another model of two converging arches. It questions the constructability of such an object by treating the whole as the sum of layers.

These images depict a model made of two arches. The lower arch supports the upper one, and hints at a circulation space beneath. The upper arch acts as the supports for the bleachers and as a canopy.
The first major element in the upper deck seating area is the tripod. The tripod holds up the main beam while providing space below for crowd circulation. Using a tripod, as opposed to a single larger support, reduces the visual massiveness of the member. Likewise, the individual legs of the tripods have a faceted hexagonal cross-section. The facets catch light in a way that gives the impression that the members are much lighter than they appear. The tripods are constructed of precast concrete blocks. Each block stands four feet tall and is six feet across. The fact that the block is angled means that there is only one way to stack the pieces, leaving little room for error on the job site.
The individual pieces of the tripod stack upon one another like a set of children's blocks. Each piece is fed onto post-tensioning cables like beads on a string. The cable, which is connected to the foundation, is tightened when each leg of the tripod is complete, thus putting each leg into extreme compression and holding the separate blocks in place.
The tripods establish a rhythm for the building. The front leg of the tripods are in line with the ten-yard lines, which connects the outside of the stadium with the inside. Also, a zone for circulation is created in the space under the tripods. The tripods help to designate a border line between the inside and outside of the stadium.
Each leg sits on a base to indicate that the bottom of a column is a special instance deserving of recognition. The base of the legs is the zone of human interaction. The base provides a place to sit against the column.
This beam is the showcase piece of the stadium. As with the other pieces, and the stadium as a whole, the beam design stems from the job it has to do. In the case of this beam, it must span between two members and support the upper deck bleachers. As the moment forces move through the beam, different depths are required, hence the changing curvature on the bottom of the beam. The circular voids and the thinner middle section of the beam indicate that, although a certain beam depth is called for, it does not have to be solid material. The top of the beam is stepped to receive precast concrete bleachers which span beam to beam. Finally, the beam is designed to receive the lighting system at its top.
The diagram to the left traces the moment forces through the main support beam. The moment force equals zero just left of the support on the right. This spot is the perfect place for the joint of the pieces to occur. At this point, the beam must only resist the shear forces. Also, the beam is cantilevered to help reduce the maximum moment force, thus allowing for a shallower beam.

The drawings on the right show the method of transportation for the components of the main beam. The length of the beam components are short enough to be trucked on the highway. They also act as their own trailer by simply attaching a set of wheels to the end.
This series investigates different possibilities of making the seam between the two parts of the beam. The two pieces are welded to one another at the seam. The bottom left beam was chosen because it provides a great amount of space in which to weld, it makes it exceedingly difficult for the two parts to slide away from each other, and neither of the pieces are too long to truck to the site.
The upper component is lowered onto the bottom piece. A short rod of steel is placed in the circle in the joint, and all the pieces are welded together. With all the parts welded in place, the two pieces cannot slide apart from one another.
After one beam comes together, two large beams are connected by yet another piece. This middle piece separates the two beams the appropriate distance and is formed to receive the bleacher components. By joining two beams in this manner, the final assembly has a width of five feet.
This piece connects the tripods to the support beams. This connection ties the three legs of the tripod together. At the same time, the beams rest on the shoulders of this connection piece while the protruding part of the connection sits between the two beams.
The last major piece of the assembly is the outrigger which sits in the space between the upper ends of the main support beams. The outrigger is welded to the beams with a steel rod the same diameter as the rod that welds the two beam components together. The shape of the outrigger is reminiscent of the main beam, and it also has a notch from which the lighting system or banners can span.
The components all come together and the main support beam spans from the tripod to a concrete box on two rows of columns. The concrete box transfers the load from the beams to the columns below. The rows of columns sit at the top of each flight of stairs that lead into the lower deck seats. The concrete box also contains any electrical and plumbing needs to serve the neighboring spaces that contain the press and luxury boxes.
The pieces get stacked up like a set of blocks. Each structural assembly sits 30 feet from the next one. This distance is spanned by concrete bleacher sections which tie all the assemblies together. The end result is a stadium made from a system of pieces with a clear structural hierarchy.
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