A SunCam online continuing education course

Building Rebar Inspection

by

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Slab on Grade - Inspected and Ready for Concrete

Introduction

The author has been fortunate to have been called back to part time work in semi - retirement to inspect rebar as it progresses through a new science and health center school being constructed by the state. With the drop in oil prices impacting my geothermal energy jobs, I am pleased to work with the fine ironworkers, plus the design and contracting professionals bringing this and other buildings from paper to occupancy. It is cool that they cannot pour concrete until I have approved the rebar in writing. Tips I relearned and progress photos I took during my inspection process are shared here with SUNCAM subscribers.

Years ago in New York City I spent time designing reinforced concrete foundations, and later inspected rebar on cast in place buildings surging more than fifty stories high. Rebar work and inspection has not changed much over those three dozen years.

East West Tower on 52nd Street in Manhattan -1984

A college classmate reminded me recently about attending my fifth year civil engineering reunion, where I impressed my Department Chairman with my career success; and then my tenth

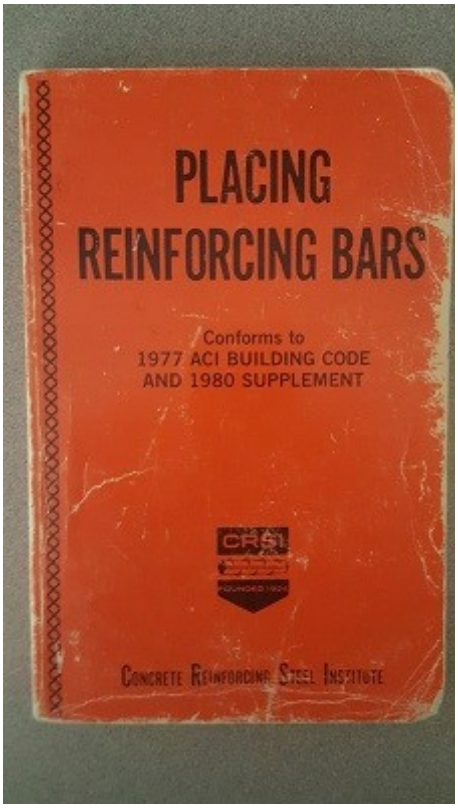
year reunion, where the professor said "So Pete, what are you doing now?" "Inspecting rebar" I replied. "Ha Ha Ha. - No what are you really doing?" "I am really inspecting rebar!" I loved being in the field and later used that experience to become a successful real estate developer and consulting engineer. Excellent reinforced concrete professional engineer designers spend plenty of time in the field with inspectors making sure that their work is implemented properly by the ironworkers.

In the 1970's and 1980's, concrete design was by two methods, Working Stress and Ultimate Strength. Today there is more software available for design, but physical in-the-field inspection remains as it has been 40 years ago and earlier. The Daily Field Report remains the document of record before the forms can be filled with concrete.

Many times photos or video are used to record the reinforcing assemblies to show to the office designer and ultimately the owner and representatives. But without interpretation that the photos meet the design requirements, they are insufficient. And taking pictures at all angles to show every possible view is almost impossible. It would be easy to have important overlap or clearance features hidden. So a summary of the work for the day (or for the proposed next concrete pour) verifies that the rebar is approved.

Handwritten reports (scanned or turned to pictures) are routinely texted or emailed to the Inspection Company office for typing. If not they may be typed on site in the contractor's trailer office by the Inspector.

Expect the General contractor and the Design Engineer to review these reports, and be ready to answer questions where uncertainty or ambiguity exists. Having photos like the ones in this course may help remind an Inspector about what was approved a few weeks earlier.



Old field handbook.
Still mostly relevant.
Modern books also available.

Building rebar differs from highway bridge structure rebar because it is not exposed to weather or winter deicing salt products that could corrode it. Building rebar is not green epoxy coated like its outdoor counterpart, used especially on bridges. It is commonly 60,000 psi tensile strength in sizes from number (#) 3 bars for ties 3/8" diameter to # 9 bars for columns 9/8 = 1 1/8" diameter, and each manufactured bar is labeled for strength and size.

The Concrete Reinforcing Steel Institute describes American Society of Testing Materials (ASTM) identification markings such as manufacturer, grade bar size, etc. here:

http://www.crsi.org/index.cfm/steel/identification

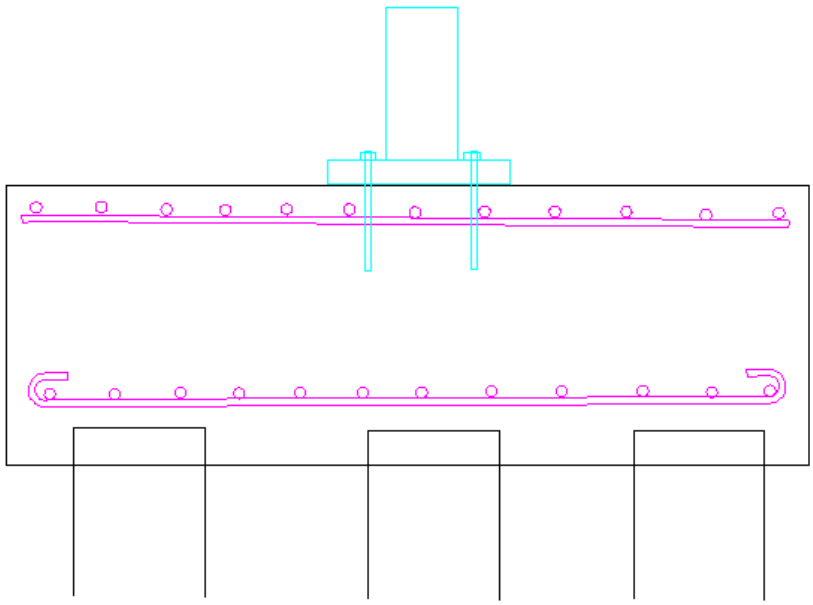
The experienced inspector can instantly recognize the difference between #5 and # 6 rebar without reading its stamped imprint marking.

Some projects specify that a professional engineer must inspect the rebar before it is hidden by concrete. X-raying is not always conclusive.

Rebar marked Number 6 (¾" in diameter)

Pile Caps

Building Pile Caps are thick solid concrete structures with rectangular sides that distribute point column and pier loads from above onto piles embedded in soil or bedrock. These are usually the first components of a building that a Rebar Inspector analyzes in the field. They may be rectangular, triangular or other shapes in plan to transfer the load from above to the desired piles.



Typical Reinforced Concrete Pile Cap

Elevation View of 180 degree Hooked Bottom Bars and Straight Top Bars

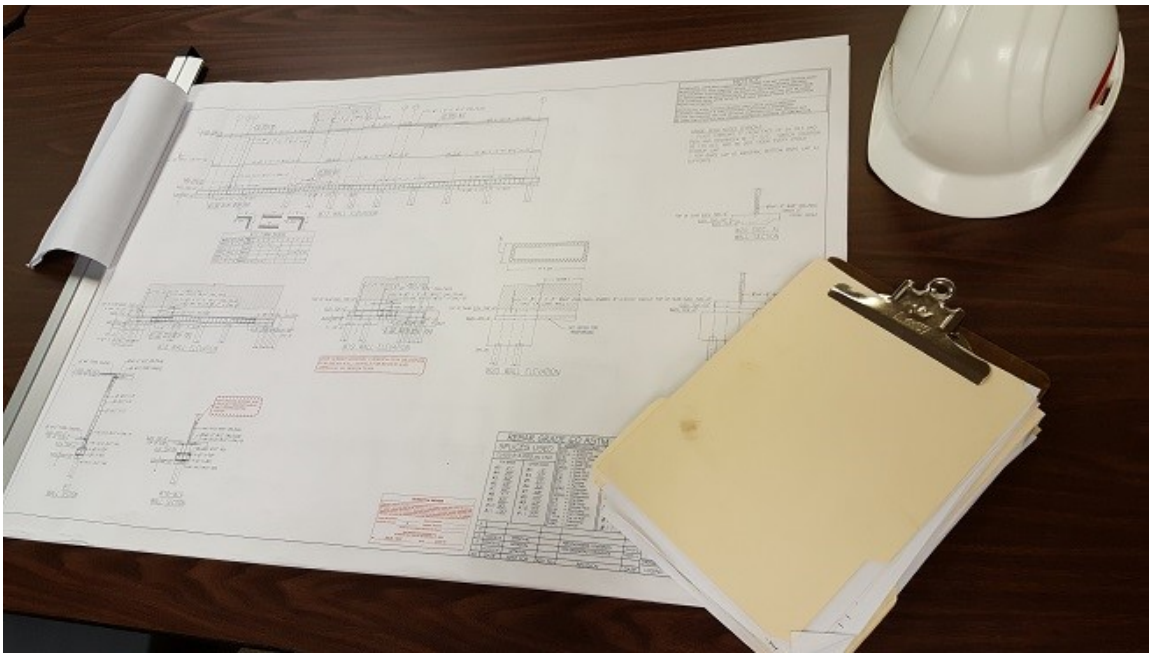
Top and Bottom Grid of Rebars in both directions- ready for concrete

Reinforcing Steel Bars provide the tensile strength to resist vertical, shear and moment loads to the concrete, timber or steel piles below designed to minimize settlement.

More than a century ago the famous foundation engineer Daniel Moran responded to the question: "Can you design a caisson or pile that will have zero settlement?" "No" he said "If a fly lands on our greatest caisson structure, that caisson will settle. Settlement will be miniscule, but it will settle. It is the reasonable tolerance of some settlement that we must accept."

When pile cap rebar is being inspected over the previously driven piles to acceptable resistance, there are a few aspects to address. First, the inspecting engineer is not the designer, and the job is to ensure that the finalized structural design drawings S-100, S-101 … S-204 … S-506, etc. have the required amount of reinforcing shown and intended. These drawings are supplemented by the approved shop drawings that the inspector and iron workers use in the field.

While shop drawings may show 72 # 7 @ 6” on center, the inspection report need not show the count of 72 unless so directed. It is usually sufficient to state that the rebars extend over the specific required location as #7 @ 6” o. c.. Be sure to document exactly where the rebar structure is, according to coordinates on the plans. For example: Two Pile Caps at 4/D and 4/E.



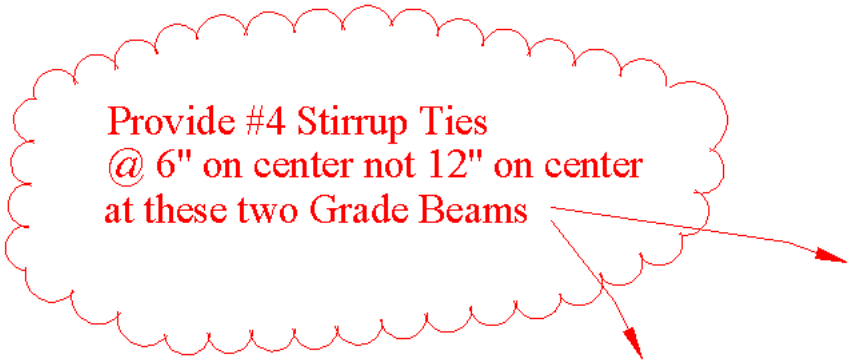
Shop drawings made by rebar manufacturer/contractor,
based on structural drawings and approved by structural designer

Experienced ironworkers who may claim that "There is too much rebar specified here compared to what is needed for this kind of pile cap" are to be smiled at. Then all the required steel is to be installed prior to approval to pour (not place) the concrete -in real life lingo. Inspectors generally only communicate with the foreman or superintendent.

If there is any question about what is being seen in the field, and what was required by the designer, the inspector is expected to contact the designer in his or her office to be certain of clarity and to receive written approval for any unforeseen variance. It is simple enough to use one's smart phone to take a picture and email or message it to the design office responsible for interpreting ambiguous aspects of the rebar assembly.

Added openings, temporary or permanent, utility conduits and other surprises to the typical detail section do not often occur in the initial pile caps being inspected. But a pile can be driven off plan location as the pile driver aims for blows per inch while the pile angles to the side. Sometimes additional piles are needed. Inspectors must check for updates to pile cap designs, in case the original designs have been superseded due to pile offsetting or final cutoff height elevation change.

Redesign is through revision response to the contractor's Request for Information (RFI) form paperwork. Redesign can involve sketches on smaller paper sizes than standard 24” x 36” prints. Be sure to work with latest drawings. Changes may be shown in red and/or cloud bordered.



Note this steel H pile, not in the exact location desired by the initial floor plan.

Steel H pile in pile cap is twisted and out of location.

In an ideal world, rebar shop drawings R -1 … to R 14A, - prepared by the contractor's rebar subcontractor/manufacturer and approved by the design office should conform perfectly to the design drawings. Anticipate the manufacturer's shop to provide standard grade 60 rebar with 60,000 psi strength. Ironworkers in the field (formerly known as lathers) do not use both shop and design drawings simultaneously. They insist that the approved shop drawings are their guide and that their job is to install the amounts of rebar trucked to the job site at the spacings and in the positions shown on the shop drawings they have out in the field with them.

If budget time allows, the dedicated inspector will compare shop drawings and structural design drawings as the rebar is placed to ascertain conformity. For minor discrepancies, and to allow especially congested rebar to all be placed, the shop drawing adherence is usually sufficient. But if a noticeable void and especially if insufficient development length is observed, the structural intent should be addressed.

If an error in approving a shop drawing that omitted essential rebar is observed, the inspector and design engineer will insist that the required additional rebar be installed, and the scheduled pour be postponed until such corrective actions are implemented. An example would be mats of rebar with no splicing overlap that would be a sure location for a future concrete crack, such as this example that was rejected and redone because the rebars on the left were incorrect.

Rebar was too short against smooth dowels without overlap.

The rebar shown above was rejected - until entirely redone at great cost, because it was not done correctly the first time. And the form should not have been closed without inspection.

The experienced rebar inspector (and ironworker) can "feel" when rebar is missing, and draw attention to whether the office rebar reviewers might have missed something on paper that is more obvious in the field. In all cases though, it is the structural drawing that takes precedence in conflicting versions.

There should be the required amount of rebar on the site as summarized in the shop drawing tables. Usually some extra bars are available for special circumstances. In general if slightly larger bars are used than are required, that is permissible, but the inspector should check other areas that might be short. For example #6 bars are used instead of #5. If the next inspection location requires #6, be sure they are all placed with no # 5's mixed in obviously.

Returning to pile cap inspection, here are other issues to consider. One is that clearance is required between the bars and boundaries. Basic concrete engineering principles learned in engineering college note that clearances are dependent on type of boundary. The inspector should be familiar with American Concrete Institute (ACI) especially Section 315-99 Details and Detailing of Concrete Reinforcing.

These clearances will be shown on the structural detail sections, not the shop drawings.

Details can be seen on plans usually in circles such as:

referring to Cross Section 5 on "S" Structural Drawing (not "A" Architectural Drawing) sheet 302 for reference.

For pile caps observed, note about 3" of clearance between any bottom mat rebar and soil below. Clearance of about 1-1/2" as designed away from the steel pile is also required because dissimilar structural metals should not touch. There are usually concrete bricks on site to support rebar mats or cages. Unfortunately they are a standard 2-1/4" thick by 7-5/8" x 3-3/4".

If 1-1/2" clearance from bottom rebar to top of steel (or concrete) pile is needed, 2-1/4" is acceptable by using bricks on piles. If the concrete to be poured (they don't say "placed" in the field) is to be of 4000 psi strength, then the brick paperwork showing 4000 psi capacity is submitted.

But be sure the top bars in assembled cages with set stirrup widths or standees will not be too high against the final concrete top surface. If 1/2" stone aggregate is present within the poured in place concrete mix, do not allow only 1/4" covered by the sandy "cream" of the concrete without stone aggregate all the way around each bar.

The standees or vertical stirrups that support the top layer of rebar offer a little flexibility; having slightly more than less clearance is acceptable. If stirrup ties are angled slightly from perfect vertical plumb around piles that were cut off higher than expected, to allow proper concrete clearances below and above, this is acceptable.

As part of the clearance inspection prior to concrete pour, and although not part of rebar inspection, the pile exposure to the rebar must be checked against soil below. A typical specified feature is that 6" of the pile should be protruding from the ground. Heights of tops of piles can vary depending on pile driving blows per inch and how they were torch cut off.

In cases where a completed pile cap bottom mat (that was set on bricks on a pile and bricks on the subsoil) shifts so that the rebar rests unacceptably on the pile cap, it can be difficult to raise it after the side forms are in place. Note that special metal chairs are used elsewhere to raise rebar above bottom boundaries, but chairs cannot sit on piles like bricks can.

Bundle of metal chairs for clearance

Ironworkers have had carpenters remove forms in such cases and have lifted rebar cages with crowbars, or jack, or more easily the fabric straps or cable hooks safely attached to the site crane. This crane is mostly used to move forms and large quantities of bundled or on-site fabricated caged rebar near or into final position in the building's interior.

Site Crane

With the rebar cage suspended above by crane, special safety precautions must be taken by the iron workers when slipping the bricks back on the piles to support the rebar weight and give it clearance. Cranes moving heavy objects can be quite silent. If the inspector cannot see the crane operator or the worker directing the operator, they might not see the Inspector, so be aware of crane work.

Of course the inspector never touches rebar to move it except to walk upon it when necessary (not for pile caps) or hand lean on it to observe it all. The inspector never touches concrete bricks or does any manual labor in the realm of the trained unionized laborer, carpenter, ironworker or their apprentices.

In cases where piles have been driven outside their planned position, a revised pile cap drawing will be issued showing a larger pile cap than originally designed. New shop drawings might use the original say eight foot long rebars that must now be eleven feet long by proposing

a splice and new 180 degree hook bends as shown. It is rare to see a smaller pile cap proposed. And formwork slightly larger than required that will be buried is often implemented.

Hooks are governed by the ACI 318-11 Section 7.1 Standard specifying 90 degree hooks have a length of 12 bar diameters (a # 6 hook will have a 9" hook length). 180 degree hooks can vary from 6 to 12 diameters as designed. In the field the iron workers refer to 180 degree hooks as "candy canes".

If other steel is present in a pile cap before a pour, it is acceptable if it is a steel snap tie to hold the forms in place by tension. Tie -wiring from the iron workers reel on their work belts is of course permitted, and occasionally steel bands, (to pull down bent bars into proper position) are allowed. Other plastic wood or loose concrete, lunch garbage and leaves must be removed prior to the pour.

Usually all pile cap rebar can be inspected from above after the side forms are in place. If visual observation is not possible, the inspector requests that interfering forms be temporarily removed. Normally, rebar is approved before forms are closed up that hide a later inspection.

For further information on pile caps and their design principles to be followed, consider:

http://osp.mans.edu.eg/deepfoundation/ch10.htm

Completed and form stripped Pile Cap ready for Steel Column above

For each component described in the course, **Sample Inspection Report Forms** are provided, fictionalized from real reports written by the author. Actual reports might have additional notes and comments. Inspectors are encouraged to discuss mount of detail required in a report with the client and general contractor. The first is a sample Pile Cap Inspection form below:

Sample Daily Field Report of Building Rebar Inspection

Project Name: _____ Date: X / XX / 16

Client: _____ Weather: Overcast

Inspector: _____ Page Number 1 of 1

Work Area Inspected: Pile Caps
Drawing References: S-100, S-402, R-1, R-4.

Rebar Inspected:

Pile Cap per (PC- 3) at corner 5/A # 8 @ 8" bottom with 180 hooks each way
5@ 8" top each way on proper standees
Comment: All 4 Piles are exposed 6" above grade.
Bottom rebar has 1- 1/2" to 2-1/4"clearance above piles

Pile Caps per (PC -2) at 2/A and 3/A
Combined into a single larger cap per PR 6220 and Sketch 14
8 @ 6" with 180 hooks each way
5 @ 8" top each way on proper standees
8 # 9 vertical column dowels at each of 2/A and 3/A columns
Comment: All 10 Piles are exposed 6" above grade.
Bottom rebar has 1- 1/2" to 2-1/4" clearance above piles

Triangular Pile Cap (PC-7) at 4/B
8 @ 8" bottom with 180 hooks each way
5@ 8" top each way on proper standees
Comment: All 3 Piles are exposed 6" above grade.
Bottom rebar has 1- 1/2" to 2-1/4" clearance above piles

Rebar above is Approved.

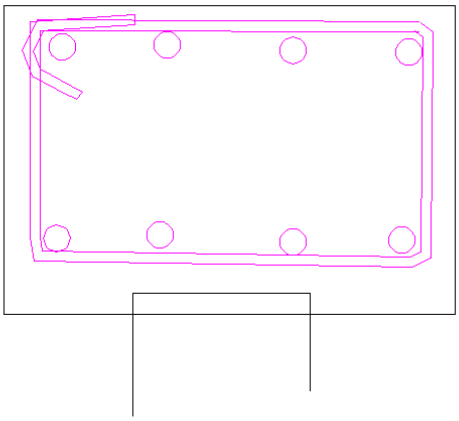
Grade Beams on Piles and on Pile Caps

Piles ready to accept Grade Beam above without a Pile Cap

The footing portion possibly above a pile cap and under a wall, and the footing beams under straight slabs are both referred to as "Grade Beams". Structurally, they are continuous beams over supporting piles, with heavy rebar on top and bottom. Horizontal Rebar is tied together with smaller sized stirrups that wrap around them.

Grade beams rest on the grade below and may be formed or not depending on location within a slab or not. For piles as shown the compacted process stone between them is expected to settle and not give bearing support, so rebars must carry the span loads.

Grade Beam Rebar with 135 degree bent Stirrups over a Pile



Grade Beam on Pile

For exterior wall grade beams, usually poured after the pile caps, observe typical longitudinal top and bottom bars within stirrup ties of # 3 or # 4 size. Under a wall, expect vertical dowel rebars to protrude above the top of the grade beam to secure the future wall above.

Dowels with orange plastic safety covers in grade beam ready for wall above

Dowels are reinforcing steel bars that connect separate concrete pours. They are commonly form saver types as specified on the shop drawings to provide linkage between the first bottom pour and the future pour above. Form saver dowels feature threaded socket connections. Form savers would be approved by the design engineer as a substitute for a continuous dowel with size and embedment length as specified on the structural design drawings.

Form saver dowels can be a major inspection issue. The Structural Drawings might not mention them. But the Structural Cross Sections will show on which face to install them. The Shop Drawings will have tables showing which pieces connect to each other and commonly, where the 90 degree hook bends will go. These tables, approved by the designer, will specify lengths of each socket piece installed first and the screw in rebar installed for the next pour.

Form savers are better than “wet sticking” rebar before the concrete sets (which is difficult to quality control), and form savers are superior to post pour drilling and epoxy of dowels into hardened concrete, with less development length, usually under one foot deep.

Form savers that come in two parts are listed in the separate shop drawing table with dimensions and bending details into slabs or pours beyond. The threaded socket in the lower portion of the grade beam in this case will have a protective plastic cover so that the concrete does not enter into the threads.

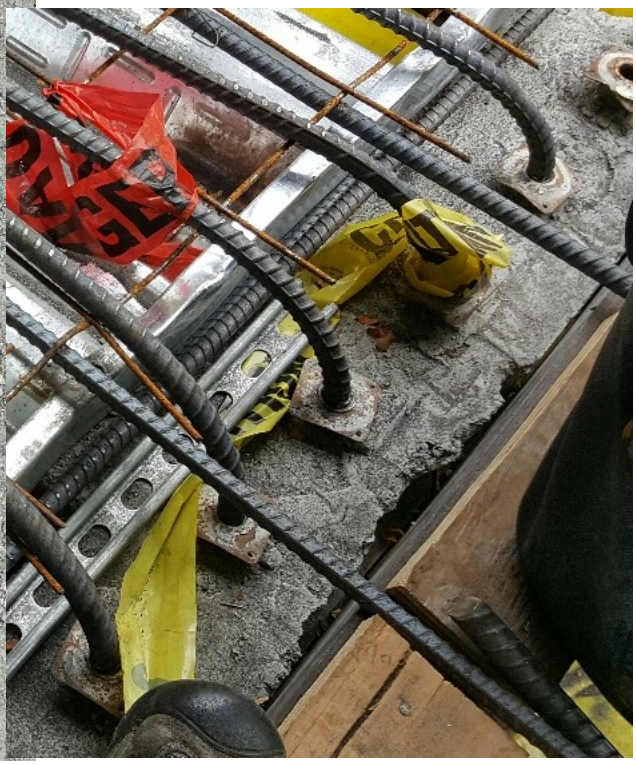
Form savers make it easy to attach dowels up against side forms, flush with the final horizontal surface of a concrete pour. Finishers trowel off the top of the vibrated concrete - even with the plastic cover over the threaded socket, without having to finish around one piece protruding dowels.

When the next wall or other pour above is prepared, the upper form rebar with thread is screwed into the socket below.

Form saver sockets covered with tape

For dowels on sides of wood forms, form savers eliminate the need to drill holes in the reusable form panels. Where 90 degree bend hook top bars are required, it may not be possible to screw in 12" x 12" long bars into a 6" on center spacing for example. Expect manual bending with a bend bar after the threaded rebar has been screwed in. It is not uncommon to see a sledge hammer used to be sure bars are bent within clearance tolerances after the bend bar is used. But torch flame heating of rebar to assist in bending is strictly prohibited.

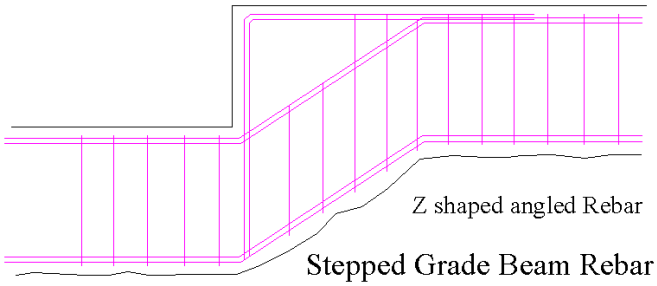
Socket of Bent Form Saver



Bars Bent down after threading

Grade beams have similar clearance concerns to pile caps. Grade beam bottom rebar may not rest on piles or come too close to soil. Usually the grade beam top longitudinal bars and stirrup ties are up even with slab top bars if not supporting a wall. No dowels are involved.

Grade beam vertical stirrup ties must be spaced apart as specified, sometimes at a closer center to center spacing at critical ends or intersections, with pile caps below where moment and shear loads increase. Be sure the two ends of stirrup ties (always around the bars) are overlapped in 90 and 135 degree angles. For a change in grade to a lower level, Rebar will be "Z" shaped. Note that grade beam end anchoring and corner bar requirements will involve more than the typical rebar amounts across the normal spans. Grade beams sloping to lower stepped elevations with specified Z sections must have dimensions verified.



Freshly poured Step - Down Grade Beam,
with Vertical Dowels in place and "Z" rebars embedded.
Check drawings if top bars extend as Z angles, like the bottom bars shown.

Sample Daily Field Report of Building Rebar Inspection

Rebar Inspected:
Grade Beam 204 per Detail 3/S-312 at 1 line, from C to E.5
4 # 7 top and 4 # 7 bottom
4 @ 6" stirrups
Vertical Dowels: # 6 @12" inside face
Comment: All 4 Piles are exposed 6" above grade.
Bottom rebar has 1 1/2" clearance above piles
Rebar above is Approved.

Reinforced Concrete Walls

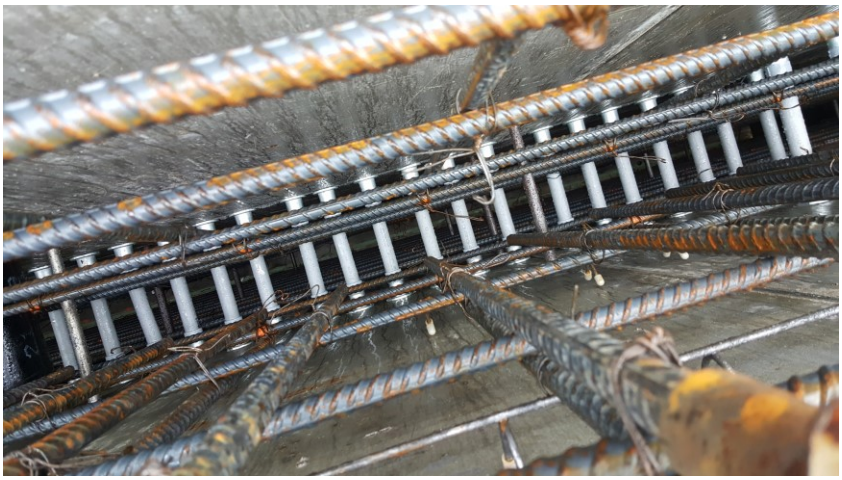
Ironworker with safety harness just below socketed form saver dowels above.

Expect to see inside and outside faces on larger sized walls. Do not confuse inside mats that might have different dowel and rebar size requirements with outside walls that do not, based on design tension and compression forces. The usual procedure on short frost walls is to place a form, place the rebar with one or two faces, and then place the closing form on the other side. The inspection for conformance can occur from above.

Short Wall inspected from above.

The wall shown above had the outside face approved, but the inside face could not be approved until it was shifted right and wire tied onto the form steel snap ties. Side wall clearance must be a minimum and maximum distance from form surface. Clearances and overlap splice and hooking dimensions are all available on the structural drawings to be followed.

Note that the Shop Drawings will be shown as Elevations for walls and not redundant in plan view. Check building coordinates on Shop drawings in case elevation view is from outside and not inside.



For larger walls, both faces must be inspected for completeness before the second form is placed. Trying to look down a deep form with flashlight is unacceptable, because lower horizontal bars will be out of sight.

Having a sample panel removed for inspection is also not done.

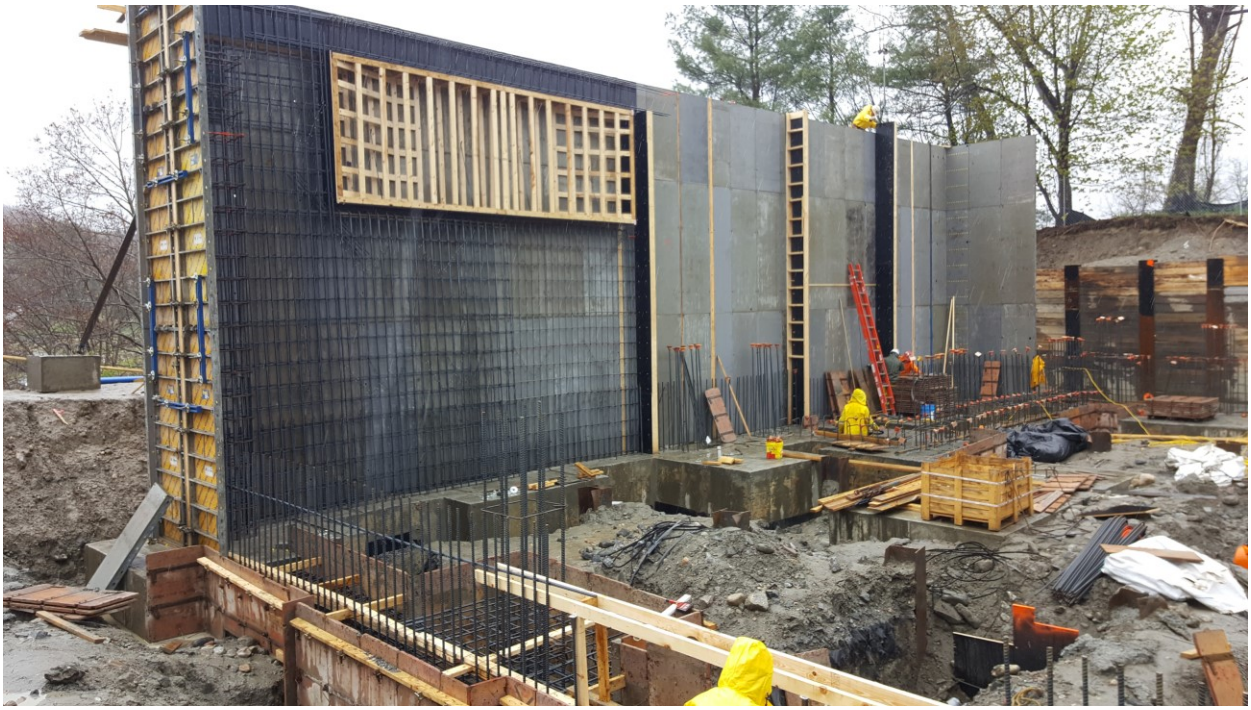
Looking down from the top. Lower rebar is not visible.

Inspectors writing Daily Field Reports before concrete pours may occur, do not verify rebar is in place if it was not seen. For inspection that is part time only, it is important that the inspector observe the rebar when forms are open to view without delaying scheduled closure by the carpenters. Never climb on forms, but only on approved and finished scaffolding

Besides the normal single or double faced rebar mats, pay special attention to ends, construction joints, corners, steps, dowels above and below, and all openings greater than 12".

When distinguishing between inside wall faces and outside wall faces, refer to building interiors. For basement retaining type walls, refer to proper cross sections for side against backfill versus side open to a room.

Inspecting Wall Corners before forms are closed

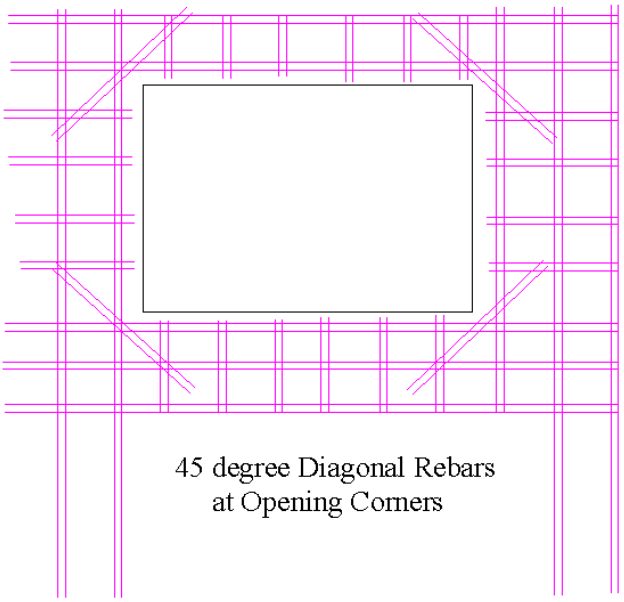


Large Louver Opening in a Wall

Wall openings such as window or the louver openings (see above) in mechanical rooms present challenges. The typical wall reinforcing will be interrupted in pattern and supplemented with extra rebar at the opening interface. If a shallow beam space is located above, expect to see stirrup ties to both faces. Sometimes candy cane 180 hooks are placed at the junctures to the sides, above and below if space allows.

Clearances can be tricky at multiple openings where there is no room for error in the necessarily congested design. A common requirement is to have 45 degree diagonal straight bars surround an opening in addition to the regular rebar. Be sure to check if diagonal bars are specified for the inside face, the outside face or both.

Construction Joint stops where concrete will be poured are also specified, and would not be in the middle of a big opening as shown.



45 degree Diagonal Rebars
at Opening Corners

The design specifications state where Construction Joints can occur, not too close to corners or pilasters, etc. For a 12" wide wall with two faces of steel, instead of form savers, smooth greased bars are preferred. Holes are drilled through wood boards, not wider forms. By greasing the ends not in the concrete first pour, the 12" wide wood can be more easily slipped off. Where # 5 horizontal bars at every 12" on center are required, expect to see #6, (3/4" diameter) smooth greased bars used instead at the construction joint.

Smooth Dowels at Wall Construction Joints

Top of wall dowels should not be "wet stick" stuck into the pour during concrete placement and after vibration. Instead, properly placed protruding dowels or form saver dowels will result in better quality control and pre inspection approval. Shop drawings might not show which face dowels should be placed. Refer to the structural details to be sure they are placed on the correct inside or outside face at the top of the wall. Typically, outside face wall dowels will be 90 degree bent into future floor top of slab mats.

These top dowels may need subsequent second inspection after the wall forms are closed, so that they can be wood form suspended at correct top elevation and plan position.

Form Saver Socketed Dowels at top of Wall Pour inspected from Scaffold Note that horizontal screw bars for both ends are above the pour and used to hold forms only, not in the Rebar Inspectors Purview.

The inspector climbs a ladder (with two hands always) wired at the top for stability, and walks along handrail bound scaffolding across the entire length of the wall to be inspected and poured.

Be sure that socketed or other 6" on center dowels are not 8" o.c. Otherwise undesirable drilling and epoxy gluing will be required before the next pour. Masonry or shear wall dowels will have different arrangements than typical concrete structures above. If there is a request to omit rebar so that the vibrator can be lowered more easily, be cautious of replacing it later. Where a 24 foot high wall as shown is poured, and vibrator length is limited, expect form opening ports to allow access that do not disturb the rebar.

Vibrating Tool ready for use. Might not be inspected by rebar inspector.

Vibrator used on a different job (after rebar approval)

Sample Rebar Inspected:

K line Wall (W-5) Section B at 1 line, from D to F

5 @ 12" vertical and horizontal each face

6 greased smooth joint dowels both sides both faces

Vertical form saver Dowels (5TH05):

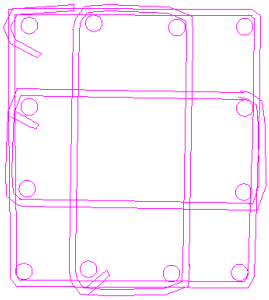
#5 @12" threaded inside face

Rebar above is Approved.

Piers and Columns

Pilaster Pier at Wall with Closer Stirrup Spacing at Top

These rebar cages are not tied to walls and will feature larger vertical steel sizes (like #8 and #9 bars) with stirrups that bind around the outside and also interior stirrups inside the mid bars as shown above and below.



Pier Cross Section Plan
With Inside and Outside Ties

Piers for future columns above.
And with steel column embedded (left)

Stirrups are usually closed with 135 degree hooks. Expect large dowels below and 90 degree bent hooks above, where it gets congested and can represent pour and vibration challenges. Note that the structural steel column extending down through the center of the pier is unusual and may have been a design error. But the rebar must be installed and inspected never the less

Extra room is always left for anchor bolts in piers supporting steel columns above. Eight foot or taller pier, pilaster or column supports should be inspected before forms are closed, and not from above. Be sure no top of pier rebar steel is removed if it interferes with large column anchor bolts that have no flexibility in position like the rebars below within small tolerances. Expect grout under column plates, but usually not in a rebar inspector's jurisdiction.

Sample Daily Field Report of Building Rebar Inspection

Rebar Inspected:

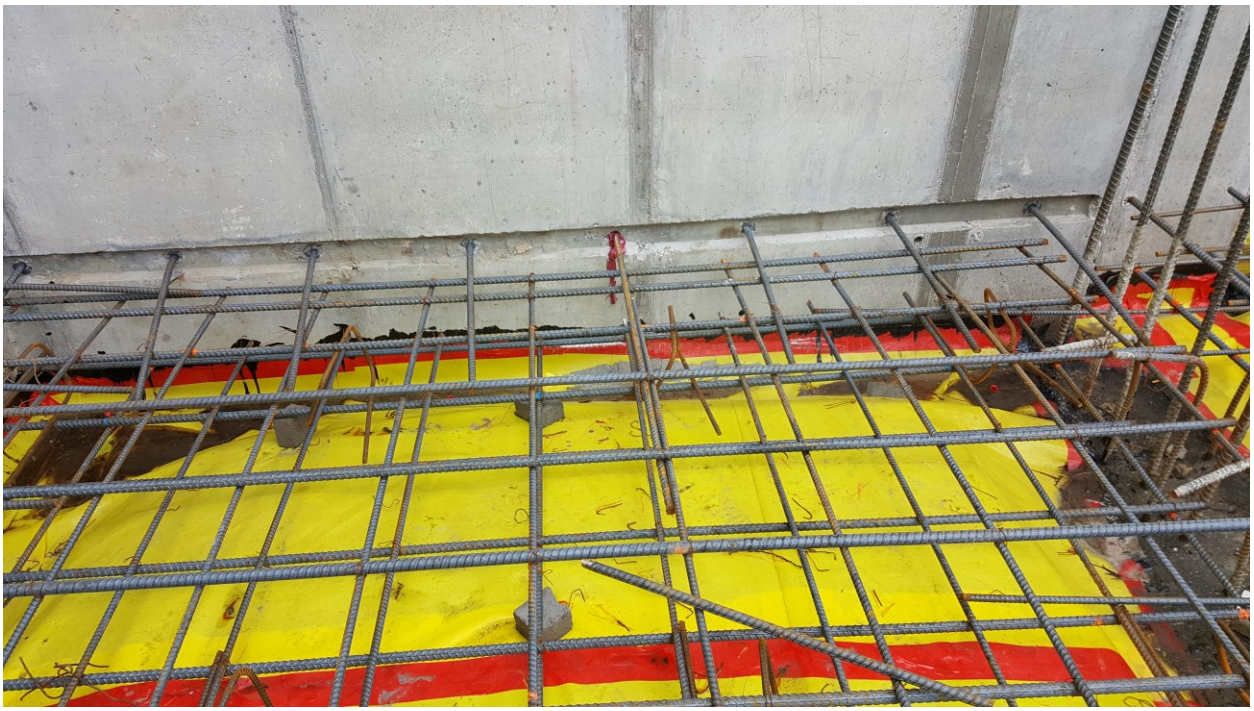
Pier 5/B.5 from (W-8): 8 #9 vertical with 8 90 degree hooks on top
4 ties outside and inside @ 12" o.c.
#4 ties outside and inside @ 3" o.c. top 18"

Rebar is Approved.

Slab on Grade

One way to ensure better work conditions and the non-mixing of soil, processed stone or mud from below into the concrete is to apply a yellow plastic sheathing barrier as shown. Concrete bricks or typical chairs can be used to prop up the bottom mat. 2 1/4" bricks above yellow plastic would be acceptable for the 3" clearance above soil. 3" clearance above the bottom plastic is not as critical as 3/4" rebar or other steel tie clearances closer to the finished floor surface.

Standee spacers support the top mat in a 14" thick slab pour as shown. These were pre bent at the manufacturer's fabrication shop, but could be bent with proper bender machine equipment on site. Hand tool benders would not be used when prefab is feasible.



14" thick slab on grade with top and bottom Rebar mats and wall dowels

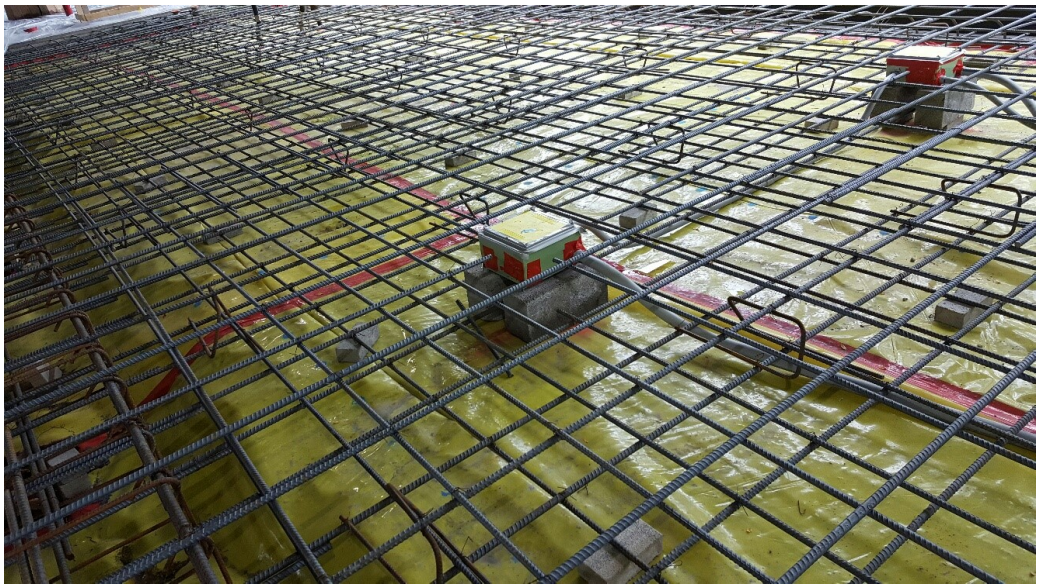
The slab is connected to the walls with proper dowels top and bottom, or top only, or not -as specified. In the photo above, red epoxy glue was used to install the dowel bar that was missing or whose form saver socket was damaged. The interior grade beams usually do not have

vertical connecting dowels to the slab, but are integral to them and supported and anchored at each end.

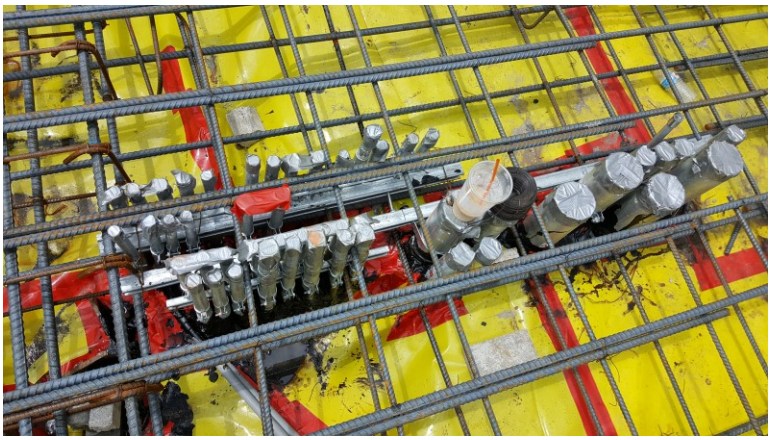
Drilling into previously poured concrete, like “wet sticking” is not recommended. Where unavoidable and with the consent of the structural design engineer, drilling and use of an epoxy gun tool may involve 8” to 12” deep holes 1/8” wider than rebar diameter. The frost wall for a minor entry door pad had side dowels omitted, so extra rebar was drilled and epoxied in place.

Drill in place and epoxy gun tool similar to caulking gun ready for rebar insertion.

The 240 yard planned pour with # 5 and # 6 each way 12” on center top and bottom as shown below has no expansion joints. Grey utility conduit is kept low away from the final concrete floor surface. Red tape was used to connect the rolled out yellow plastic sheathing above the compacted soil or processed stone. Material below is structurally considered to have no slab bearing strength, due to future consolidation. So rebar is specified in direction of span for moments on bottom at mid span, and moments on top of slab where it crosses a grade beam as its own continuous beam. Two way slabs have smaller rebar in perpendicular direction.



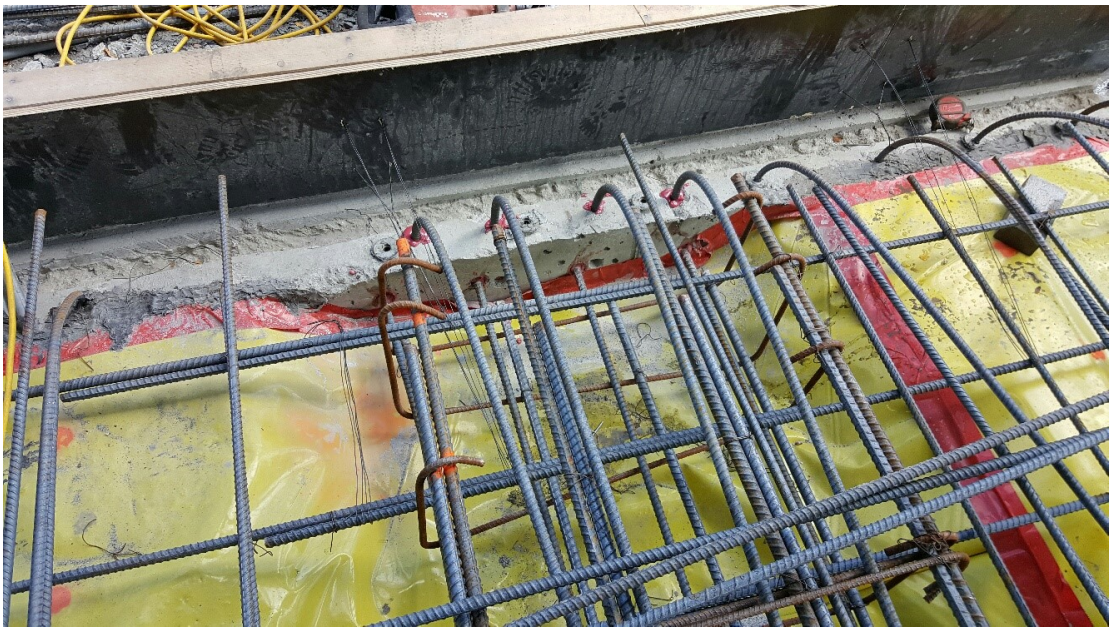
Slab with grade beams in lower left and upper right. #6 at 12" in direction of span. Utility boxes are mounted on big 4000 psi blocks. Rebar on 4000 psi bricks.



Conduit shown for power and data is not usually in the purview of the rebar inspector. Use common sense when allowing reasonable flexibility in rebar spacing and location.

Slabs can be poured directly against structural steel columns, and the 4 diagonal bars that might be required to surround an opening greater the 12" could be required to surround a column resting on a pile cap below the slab.

Grade Beam rebar across steel column base in slab on grade



Dowels as form savers & as drilled and epoxied at slab on grade and grade beam. Additional top and bottom bars were added above the bent dowels.

Sample Rebar Inspected:

Slab on Grade 1 to 4 / A to C

Bottom Bars on bricks #5 @ 12" east west throughout
6 @12" north south throughout.
Top Bars on standees #5 @ 12" east west throughout
6 @12" north south throughout.

All perimeter dowels bent into top mat. #6 @12"

45 degree # 4 diagonals 4 each in bottom mat at Columns 2/B and 3/B

Masonry dowels on W-5 wall 2/B to 3/B: # 8 @ 18" on center.

At elevator pit C/3.5 per walls (W-8, W-9 & W-10):
#5 90 bend top hooks @ 12" for masonry shear wall above
I In slab, 180 candy canes at all three elevator walls top mat.

Rebar above is Approved.

Slab on metal deck

Formerly known as Q deck for floors and roofs, galvanized metal decking stays in place, -unlike a removable form of steel or wood beneath. The 8 gauge common thickness decking supports the weight of the rebar and workers until the concrete is cast. This allows a shallower concrete pour such as 3" thick for the area shown.

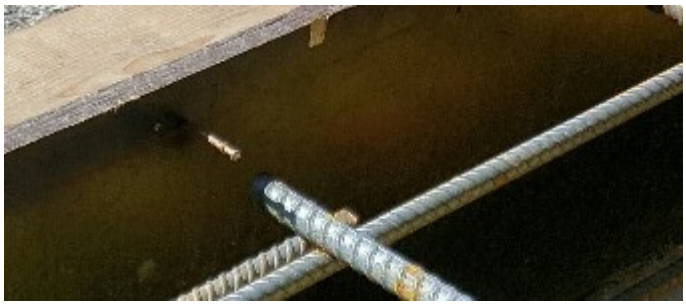
Slab on metal deck. Manhole opening has candy cane 180 hooks and diagonals.

The majority of this slab will only need 6" x 6" square wire mesh. Two panels equaling an overlap of 12" may be required at all ends. This is easy to visually inspect.

At perimeters of slabs, expect to see 90 degree bent dowels from the walls below. These would be by screwed in form savers bent into position. At corners, congestion will occur as the bar dowels are bent from vertical to horizontal. One way to hold them down within the 3" thick pour is to twist in small 1" screws into the metal deck and strap or wire the bent rebars down. Drilling holes through the metal deck and extending wire below is not recommended, because it would be visible as the ceiling from the lower level. The screws can secure metal bands that can hold down the bent dowels (#6 shown) below the slab pour surface with required clearance.

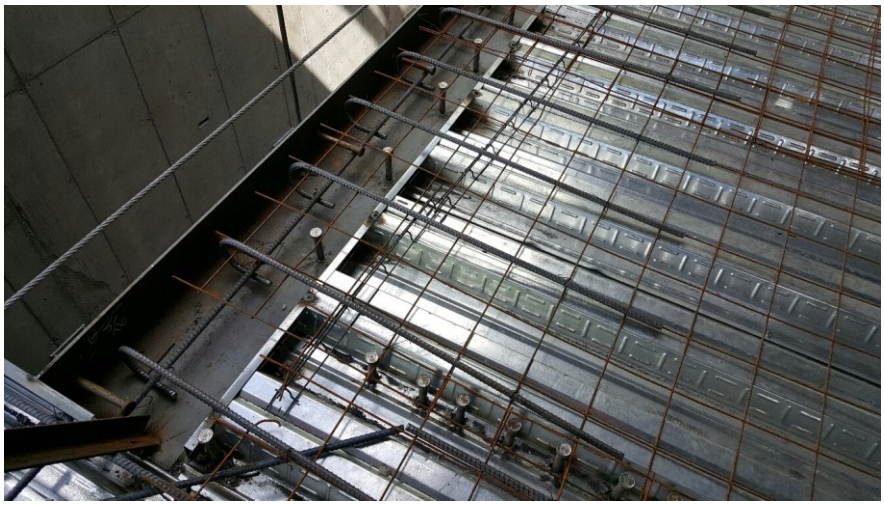
Perimeter dowels bent down and to be strapped ¾" below floor elevation

Any locations where rebar is too high relative to side nail reference final slab grade should be corrected.



Whether wire fabric or mesh is installed above or below the dowels and any interior rebar, (which will be extra reinforcing parallel to the span direction) is not important. It is the iron workers choice in a thin slab. But attempts should always be made to follow the design drawings unless assembly so impedes. Be sure wire mesh is on chairs and does not simply lie on the metal deck. Chairs should support mesh where it is not near rebar.

Sometimes a balcony or other slab area has no bottom wall dowel support available. Candy canes might give required embedment as shown.



Slab on metal deck with wire and candy cane 180 hooks

In some cases, concrete embedment below the stay in place metal deck is required around the steel columns at the ceiling below. This forms a capital or head. Openings might be needed after the decking is in place and after rebar or welded wire is placed. If decking is cut with a saws-all, be sure any nearby rebar or wire mesh is not also cut.

Sample Rebar Inspected:

Main Floor Level Slab on Metal Deck: 1 to 4 / A to D.7 per R-12.

*6 x 6 welded wire mesh on chairs throughout and lapped two full square panels at all splices
*90 degree bent #6 dowels @12" o. c. at all 4 perimeter edges.
*180 degree hook candy canes at balcony support without dowels
*All 3 steel columns have 45 degree diagonal # 5 bars 5 feet long at each corner, total of 12.
*Along the 2 line 10' long #5 @12" A to C.5
*Construction joint at D.7 line has 8' long #5 @12" dowels, 4 feet each side

Rebar is Approved.

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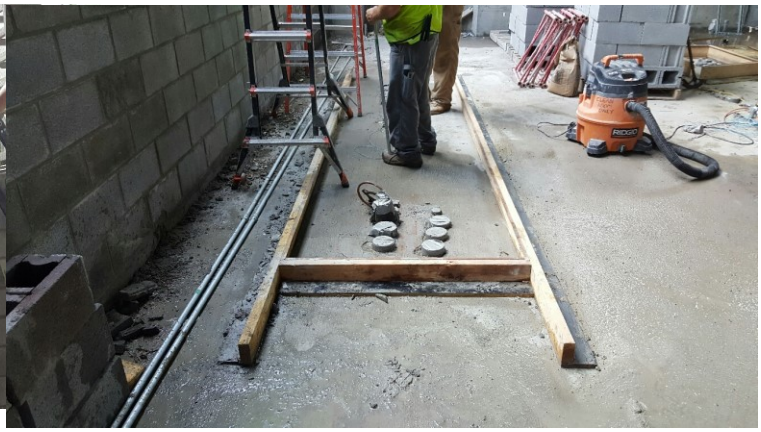
Miscellaneous Rebar

Masonry dowels were inspected from below before the concrete beneath was poured.



Housekeeping pad (non structural)

A separate masonry inspector observes blockwork. Small housekeeping pads for electrical conduit panels for example might not need rebar inspection. The rebar inspector can be asked to ascertain that the future dowels were drilled the specified 2 ½" into the slab around the top steel. Some minor frost walls may be exempt from rebar inspection too depending on client policy.

And a separate task might be for another technician to take concrete slump tests and cylinders for lab testing, and be on site during the concrete pour in the Rebar inspector's absence. See alternate SUNCAM courses concerning concrete slump testing, etc. Concrete formwork is the contractor's, not the inspector's responsibility. Rebar inspectors are encouraged to focus on their area of responsibility without being distracted by all the other activity of an ongoing building construction project.

Sample Rebar Area Inspected:

Housekeeping Pads HP3 and HP5 in lower level:
Verified 2 ½" drill depth for all perimeter # 4 dowels @18" o. c.

Embedment depth is Approved.

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New Technology

Drones are used in 2021 to tie rebar:
https://techcrunch.com/2021/03/02/__trashed-12/

Safety

Besides hardhat and orange or yellow green vest, good work boots are recommended. Walking across slab top bars is very dangerous. Expect some areas to give way to your weight where rebar is not wired down completely. Slow, cautious walking helps, or walking around instead of on top of slab rebar is best.

Rebar inspectors should not be close to heavy machinery work. Safety glasses are recommended but should not be needed. If you feel you need a safety harness, request one.

With forklifts, silent cranes, track hoe excavators and the usual civil engineering machines, chemicals, combustibles and forces of a large-scale construction job, awareness and accident prevention techniques are paramount behavior. Inspection at coffee break or lunch time when no other workers are present is unnecessarily risky.

Field cutting rebar with corresponding sparks and danger nearby

Just as the inspector checks rebar, the inspector should check personal workspace site safety conditions - with the same engineering approach to both:

"What could go wrong??"

End. Thank you.

