





Thank you Rob.

Good morning ladies and gentlemen. It is a pleasure to have an opportunity to speak to you this morning (afternoon) about how to avoid having a paint system failure on your next structural, miscellaneous or ornamental steel project.

My career has been spent working in the structural consulting, trade association and steel fabricating industries, with most in the latter. The companies that I have been associated with have clearly viewed cleaning and painting, not as a nuisance, but as an opportunity for value added fabrication. All have excellent paint facilities and staff that ensure the highest quality. If what they say about learning from your mistakes is true then I likely haven't learned much about painting since these shops have tremendous track records with few failures. They have obviously paid a great deal of attention to the items that are magnets for corrosion.

I have divided my presentation this morning into three parts.

WHY DO COATINGS FAIL? will identify the conditions that cause the greatest paint failure risks.

This will be followed by a look at the details that cause fabricators and paint contractors the most problems and are candidates for corrosion failures. I will then offer some suggestions for good detailing, fabrication, cleaning and painting practices to follow to reduce the risk of failure. During this and the previous phase I will provide some visual examples of the kind of details that cause the most problems.

I will look specifically at trusses at the end of this section since these structural members contain most of the offending details in one way or another to demonstrate some of the options.

And finally, I will summarize what you have learned today to ensure trouble free structures in the future.

The architectural tree in this slide was one of ten fabricated and erected by Empire Iron in Calgary, Alberta last summer. Besides being a very tricky plate fabrication project it also presented many cleaning and painting challenges. I'll comment more about them during my presentation.



To allow me to tailor my presentation to the audience this morning, and not offend any one group, I would appreciate if you could respond to the following questions by a show of hands.

How many engineering and architectural consultants are there in the audience?

How many that raised their hands have had the misfortune of having been involved in a paint failure?

How many fabricators/erectors are in the audience?

How many of you have been associated with a paint failure?

How many of you are detailers?

How many think that they have had details that contributed to a paint failure?

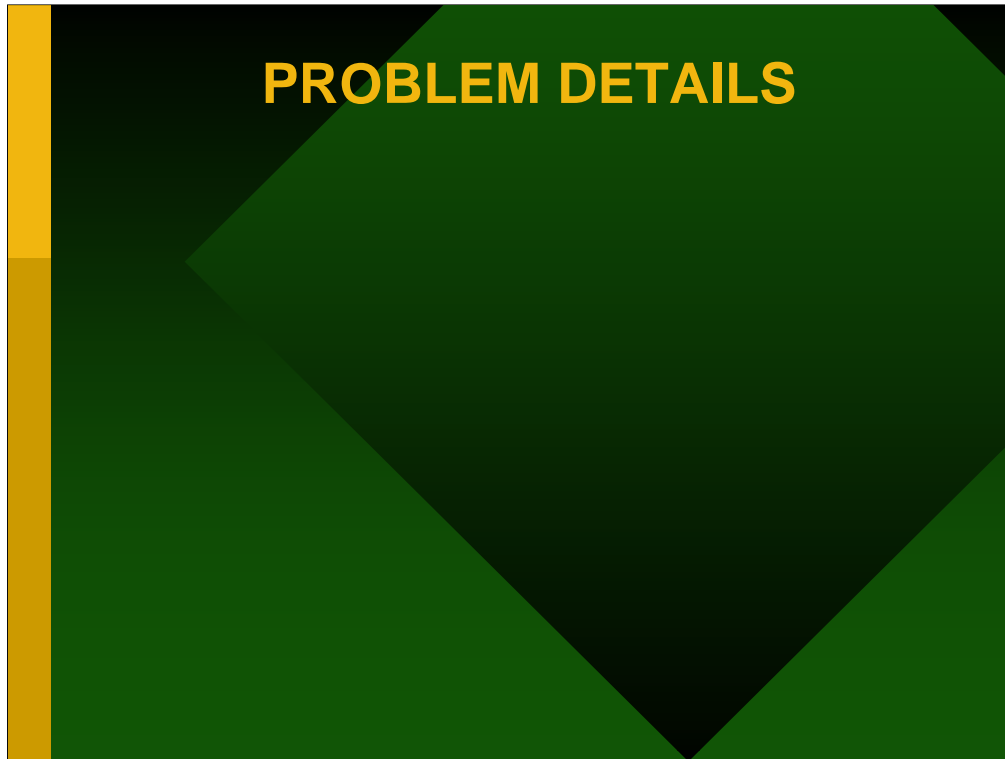
(Comment on the mix of the crowd and the number of paint failures or lack thereof)

Coatings obviously fail, otherwise we wouldn't have corrosion on many exposed structures such as atriums, stadiums, bridges and industrial plants that we see daily. The common denominator for these structures is that they are generally exposed to uncontrolled, meaning not climatically controlled, environments. At greatest risk are those structures subjected to continuous wetting and drying cycles in moderate to highly corrosive environments. My comments will therefore be most applicable to industrial type structures which many of us fabricate.

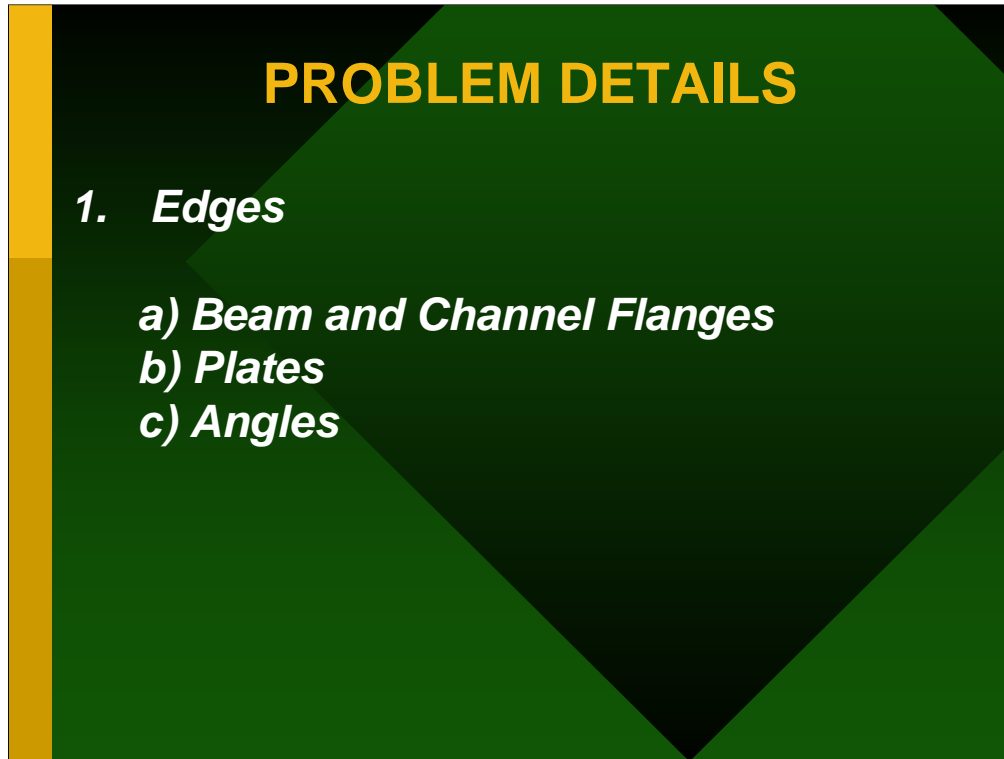
In order to understand how to prevent failures we need to understand what causes failures. Lets look at the four main reasons why some show signs of failure and others do not?



1. Coatings that are expected to perform over the long term require a sound foundation for the film. Cleaning to the correct requirement is therefore an important start to any paint job. The anchor pattern must be the correct height, the pattern must be rough enough to allow the paint to grab solidly and there can be no contamination such as oils, solvents and salts after the surface cleaning is complete. Fail to do these things and the coating can potentially fail.
2. There are numerous reasons for application failures. The coatings are applied to heavily causing runs and sags, the paint is not adequately mixed prior to use, the catalyst wasn't added to the base, the paint lines were not cleaned properly, the temperatures were too hot, the humidity was too high, the humidity was too low, the steel was too cold (a problem for us working in northern climates when outside storage temperatures reach -40°C), over coating took place too soon, the paint wasn't allowed to cure and on and on. This is the basis for a presentation all on its own.
3. During my preparation for this presentation I looked at over 1000 slides. Most of the pictures were of office buildings and warehouse type structures that would be considered low corrosive environment. Our industry has promoted "NO PAINT" for these structures since I worked for the CISC. Yet we still apply primers with regular consistency despite the fact that these structures are climate controlled, have humidity threshold limits below those required for rusting and no corrosion will occur once the structures are enclosed. The structures that are most subject to failure are those where the steel is exposed to corrosive atmospheres, acid rain, salt air and generally humid conditions. Make an error in selection that the fabricator doesn't question and you will likely have a painting failure.
4. Paint will not make up for design deficiencies. Even the most sophisticated epoxy and vinyl paint coatings cannot compensate for details that create opportunities for corrosion to occur. My presentation today will focus on this factor in coating failures. I will identify the type of details that lead to failures and what can be done by designers and detailers to reduce the risk.



No matter what structures you investigate you will find recurring details that lead to corrosion problems. I have identified seven common details that recur in most projects which I will now review. After each series of problems I will look at what you can do to eliminate or reduce the risk.



An item that is common to most details are edges. They occur everywhere. They are also among the items that need constant attention.

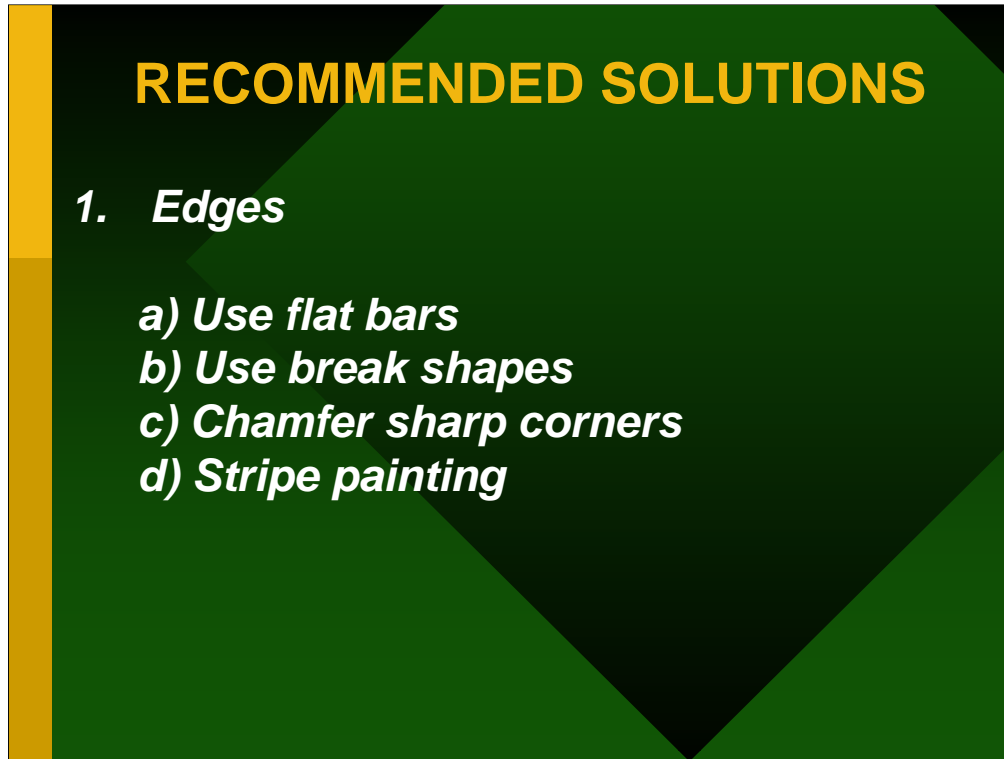
Structural sections have numerous edge conditions. Each edge is a potential problem for the painter because of the tiny width and the size of the paint fan coming from the paint gun.

The paint fan is like the palm of my hand with the fingers spread out. The paint spray is like a fan and not like a cone. If the fan is turned the wrong way you get extensive amounts of overspray with little on your steel. Painters must therefore turn the fan to get the best spray pattern. On very thin edges this is difficult to achieve.

On welded beam sections the impact of flanges increases because the edges are sharp therefore requiring greater care. It is especially important to ensure that they are treated properly to avoid the paint from failing along the edge. This occurs because the paint film shrinks during curing and pulls tight across the edges causing a thinner and more highly stressed surface. Sections subject to wear and accelerated corrosion will corrode a lot more quickly at these locations.

Plate details have square edges with sharp corners generated by the burning or shearing process. These are subject to the same internal tension forces as flanges. Details that fall into this group are gusset plates, stiffeners, end plates, shear tabs, and a variety of other bracket details, in short plate with an exposed edge.

Angles have two rounded edges at the tip of each leg but the remaining edges are sharp corners. Painters must take special precautions to ensure the paint is applied adequately at these locations.



A significant number of structures are painted annually which display no problems. We can take precautions to ensure that the edges do not become a problem. Let's look at what can be done to reduce the risks.

We can use flat bars wherever possible for the detail material. Flat bars come with rounded edges due to the rolling process. No additional work is therefore required to soften the edges. Detailers should therefore use flat bars for detail material wherever possible. On stiffeners you can eliminate all extra work to prepare the edges.

The corners of break shapes are naturally rounded. This is the desirable edge configuration and should be used if at all possible. The trade-off is cost because an additional operation which is often outsourced, i.e., Breaking, is required. On multi-coat systems this will be a worthwhile expense because of the potential risk.

Any plate component that is burned or sheared will have a sharp 90° corner. These edges need to be chamfered to provide the best condition for painting. It usually only takes a light grinder pass at the detail station to complete the task. An added benefit of softening the edges is a reduction in the number of first aids experienced by shop employees. This will lead to reduced experience ratings with you WCB provider.

Stripe painting is the application of paint by brush to specific areas of a component. This ensures that the component gets full coverage, that the paint is forced into all of the crevices and that the coating thickness will be adequate on completion of painting. By stripe painting edges you will avoid premature paint system failures. I cannot say enough about this step. Good painters make this a mandatory part of their operations.

PROBLEM DETAILS



I said I would get back to this slide. The significant detail is the broken edge on the floor plate. It could have been a welded kick plate with a full length seal weld but we wisely chose to break the edge for the full length. One of the limitations for this detail is the availability of long enough braces to avoid expensive splices.

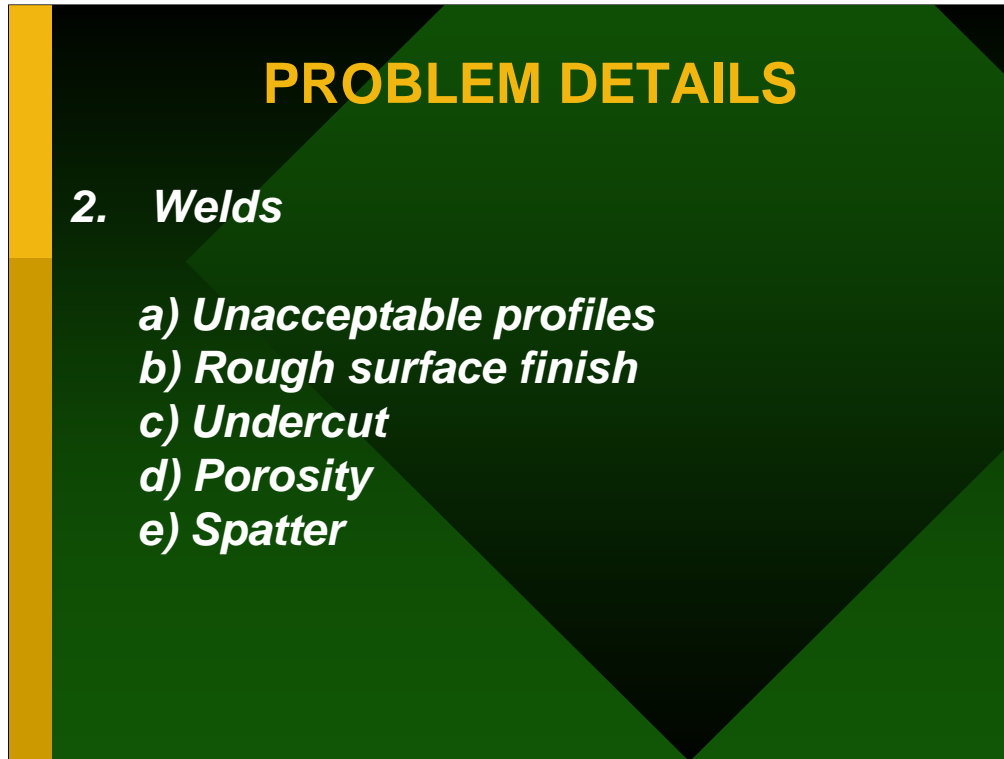


I wanted to get back to this slide because these architectural trees presented some unique cleaning and painting challenges.

The structures are about 80 feet high and forty feet wide. They were too large to run through our shot blaster. Instead of sand blasting after fabrication was complete we decided to purchase all plate pre-primed with a machine applied weldable primer to a DFT of about 1/2 mil . After fabrication was complete we solvent cleaned and touched up the pre-primed coating and then proceeded to apply the specified epoxy primer and urethane top coat.

The plates all have sharp edges which we chamfered to improve coating performance. All corners were stripe painted for complete coverage to the specified mill thickness.

The paint has performed excellently over the first year. The biggest problem for the city maintenance people has been graffiti.



Welding comprises a significant part of most structural fabrication process, on most probably between 20 to 30% of the work. Poorly made welds can contribute significantly to coating problems. Let's look at some of the details that need to be watched.

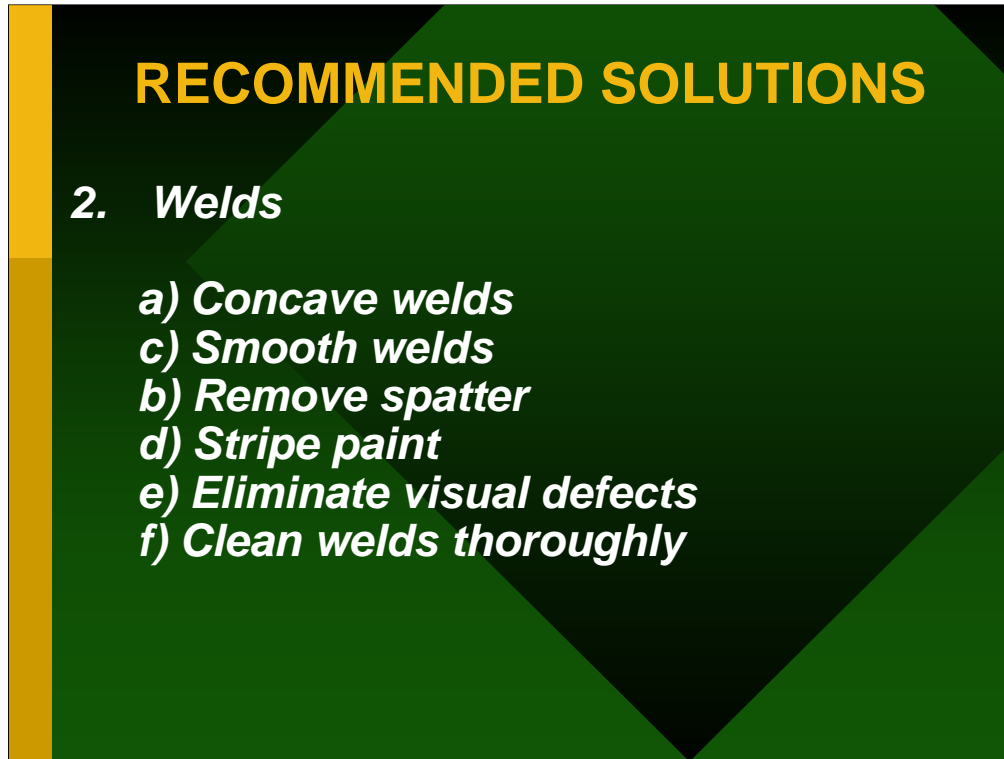
The profile of welds can be too convex causing overlap or rolling of the weld meta at the toes. The resulting crevice is a pocket for corrosion and a place for deterioration of the coating to commence.

The surface can be very rough due to the manipulation of the weld puddle. This makes it difficult for the painters to properly clean all the surfaces and apply paint. Corrosion products collect on the surface creating areas for accelerated deterioration to start.

The weld can have undercut at its toes. As a result there is a crevice that can be up to 1/16" deep that can fill with dirt, grease, oil, cutting fluid a a host of other items that will contribute to accelerating the corrosion. These locations should be carefully monitored on finish painted structures.

Many welds have surface porosity that can trap corrosive materials. These surfaces corrode if inadequately cleaned and painted.

The welding arc will sputter as the length of the electric contact is changed resulting in spatter being deposited around a joint. Some processes are more susceptible to spatter than others. These globules of metal will adhere solidly to the steel in some places but generally are only very lightly fused to the base metal. The crevices below the spatter and the potential for these globules to separate from the steel are ripe for corrosion to take place.



There are things that need to be done when welding that ensures that failures will be avoided at these locations.

Detailers and engineers can specify concave welds on their shop drawings. They have better transitions to the welded surfaces and are therefore less likely to experience coating failures.

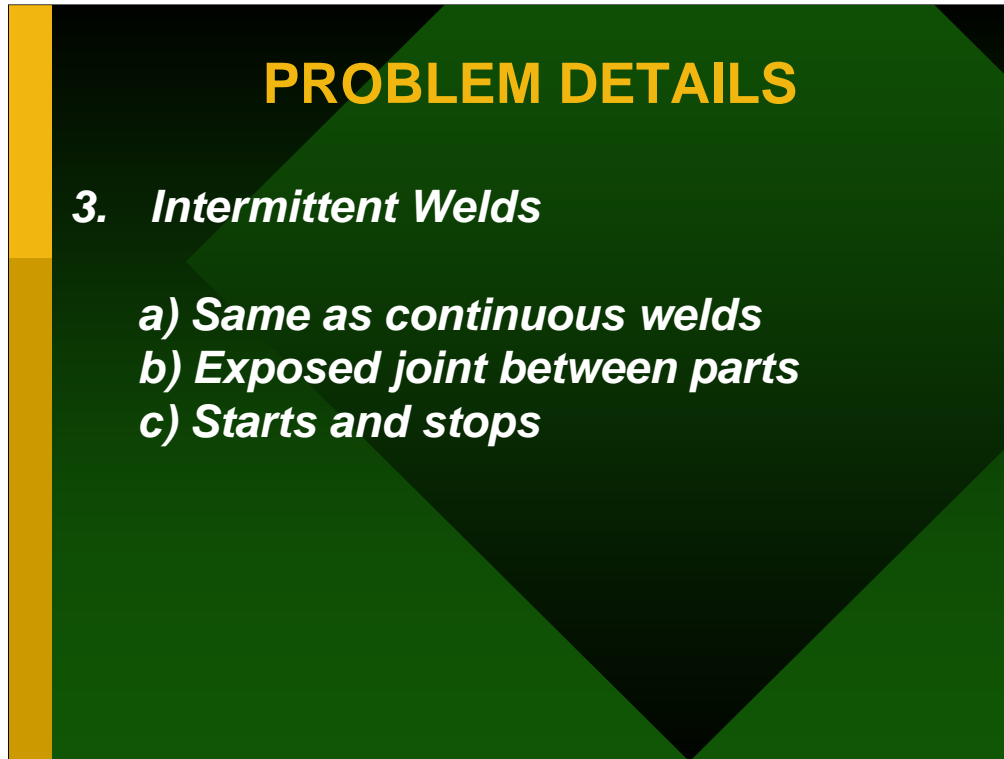
You can specify that welds should be smooth. This can be done by a general note on the drawing, showing a grinding symbol on the weld or issuing the appropriate shop practices instruction to the welders.

The fabricator must ensure that the welders are aware that a structure will be coated and that all spatter must be removed prior to cleaning and painting. As a last resort the painter must act as an inspector when the steel comes to his station and they should be instructed to remove spatter if it is present after cleaning. Spatter is not easy to see on steel with rusted areas but usually becomes evident during the cleaning process.

All welds should be stripe painted I cannot stress this process enough. This will ensure that the paint is worked into all crevices prior to application of the spray coat. In our shop all the steel is laid out on the painting floor and painting doesn't start until all pieces have been properly prepared for the application of the initial prime coat. Any welds not properly prepared during the fabrication process are caught at this stage of painting.

Ensuring that welds meet codes will go a long way to providing a final product will perform well over its life. Every shop employee needs to be aware of this objective.

Welds must be cleaned thoroughly to remove all fluxes and slag to allow the coatings to be applied to clean surfaces. If not done the welds will cause the coatings to blister and fail.

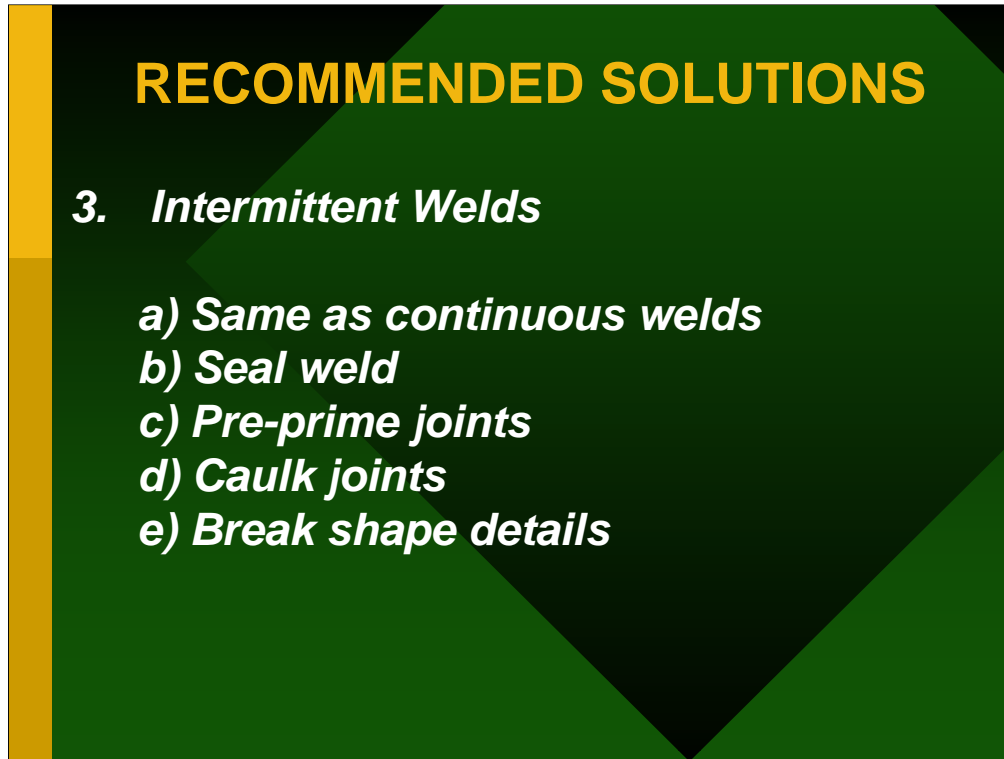


Another form of weld that is even more troublesome is the intermittent fillet weld. Welds are staggered at regular intervals to carry the required forces in a joint. The resultant gaps between the welds have an exposed joint into which moisture can seep and where corrosion can establish a foothold.

The basic weld problems are the same as continuous welds discussed previously. I will not touch on these again except to say weld by code and there should be no problem.

The joint between the welds is of primary concern. As already mentioned moisture can invade this crack and create a rust pocket. It is not uncommon to have bleeding from these type of joints as water runs through the joint leaching out the rust. Very unsightly streaks are the result.

The starts and stops are another area for concern. Care needs to be taken to remove all welding fluxes and slag from these locations, ensure that there is no undercut, that there is no overlap and that any crevices have been eliminated.



Again, these joints occur with substantial frequency in most structures. Despite this there are only limited problems when the detailer accounts for the condition and the painters follow proper application techniques.

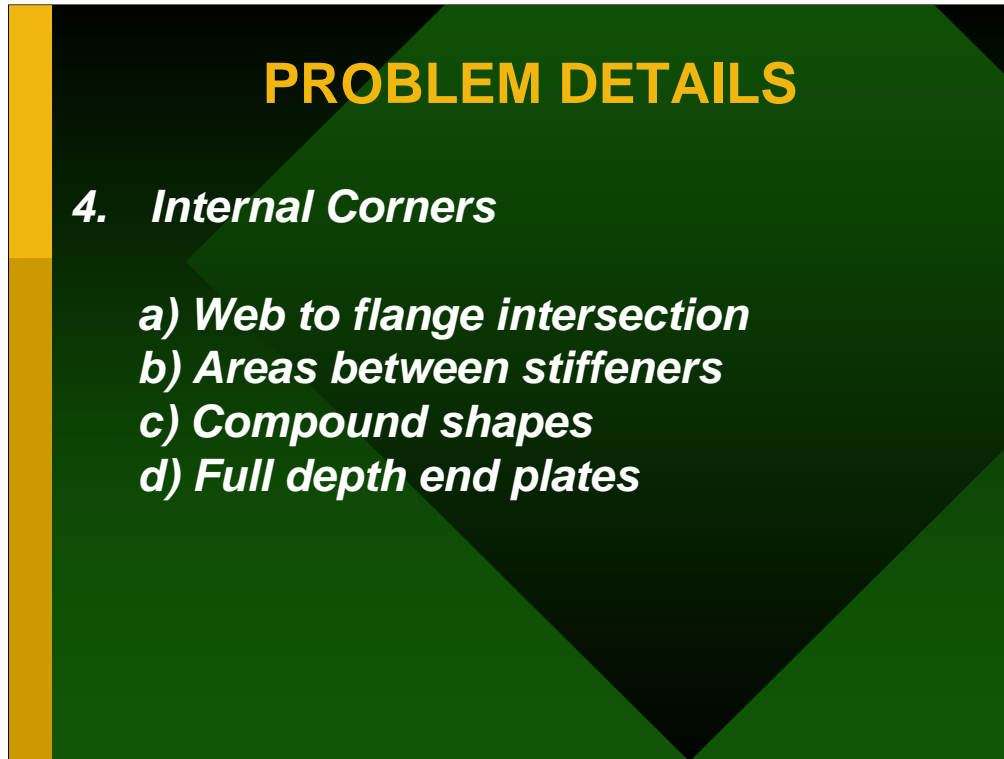
As with standard welds the detailer should specify concave profiles, smooth welds, and issue paint instructions to ensure spatter is removed and all joints are stripe painted to work the paint into the joints. It is paramount that the welds are thoroughly cleaned.

An option to ensure that moisture does not seep into the joint is to seal weld the joint that is exposed to wetting and drying cycles. Sometime both edges may be affected due to capillary action. Care should be taken when adding seal welding as this can add a significant number of hours to the project, especially when it has not been specified. The addition of the additional weld may also lead to distortion problems. Seal welding should be carefully considered before application.

In areas not subjected to wetting and drying pre-priming of the faying surfaces may prove adequate to protect the joint. Care should be taken after welding to fully clean the welds and touch up the paint at these locations so that corrosion is arrested.

Another option is to caulk these joints after welding and cleaning is complete. Caulking should always be done before painting to make this an integral part of the joint. Caulking fillets should be slightly concave similar to the welds. Again, check with the estimator to confirm an allowance has been made for this detail and that it has been specified.

It is often more economical to break a section from plate so that the joint is eliminated. In addition this creates a radiused corner which is a much better detail for the application of paint as previously discussed.



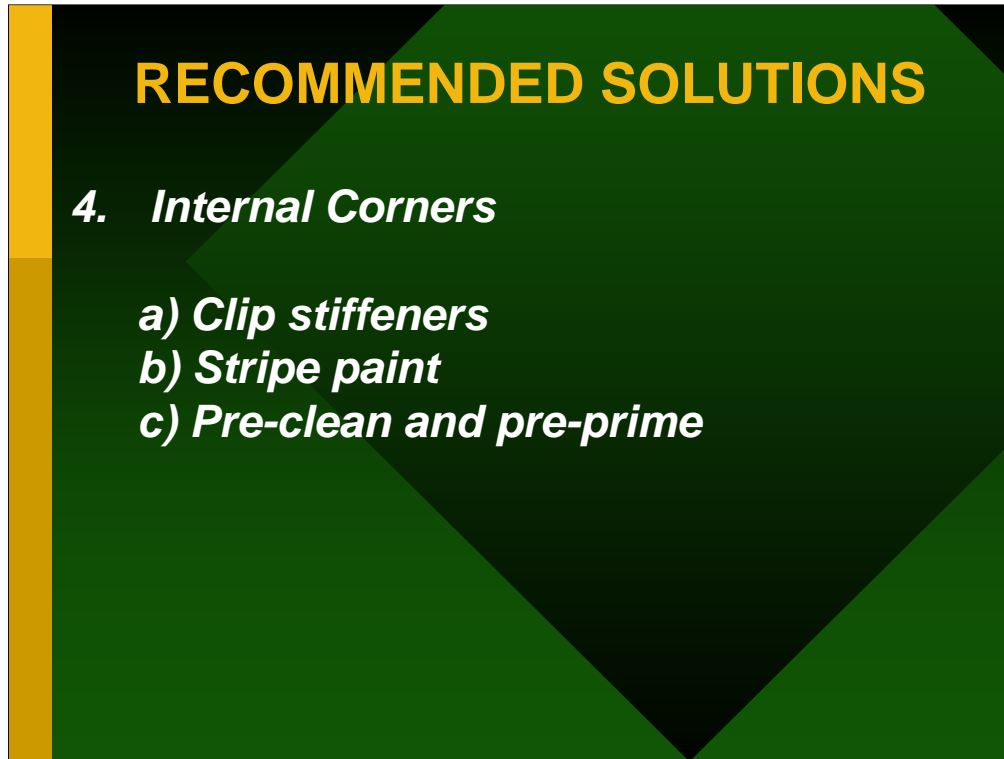
Corners occur at any location where two surfaces come together at an angle. Acute angles are most susceptible because the opening is often too small to allow adequate access for painting.

All assemblies have interior corners. As paint is applied to the faces there is overspray which often gives the appearance that these locations have adequate paint coverage. In fact the film thickness is often deficient enough for flash rusting to occur at these locations.

Another area that is susceptible to being missed is the space between stiffeners. The vertical faces at these locations are very close making it difficult to adequately paint these surfaces. As a result the film thickness may be deficient. Painters should carefully monitor these surfaces to ensure paint is applied evenly in these pockets.

Welding a couple of shapes together often results in surfaces that are difficult to access. Most blasting machines would have difficulty achieving the cleanliness that is required. Painters will have difficulty accessing and ensuring that there is adequate paint on these surfaces.

Full depth end plates create corners at the ends which are often overlooked. The beam is painted length ways with the result that the ends can be missed.

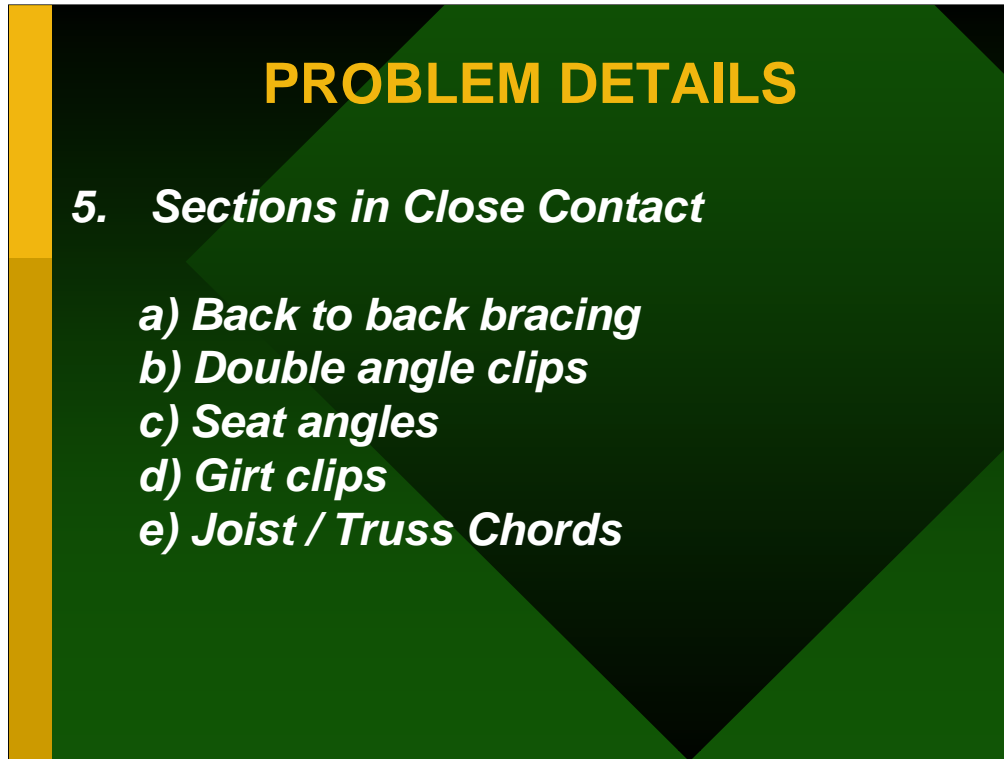


With adequate care the problems associated with internal corners can be overcome.

To ensure that moisture does not collect between stiffeners provide clips on stiffeners. This will allow any accumulation to drain.

The most significant thing that can be done is to stripe paint the areas normally associated with internal corner locations. This would generally be done at the preparatory stage.

If you can see that cleaning and painting will be difficult it would be appropriate to pre-clean and pre-prime the steel. Even though the final coating may be slightly deficient due to accessibility issues a major coating failure will be avoided.



Another common group of details that presents problems is angles in close contact. The faying surface between the members either requires full treatment or seal welding to avoid corrosion.

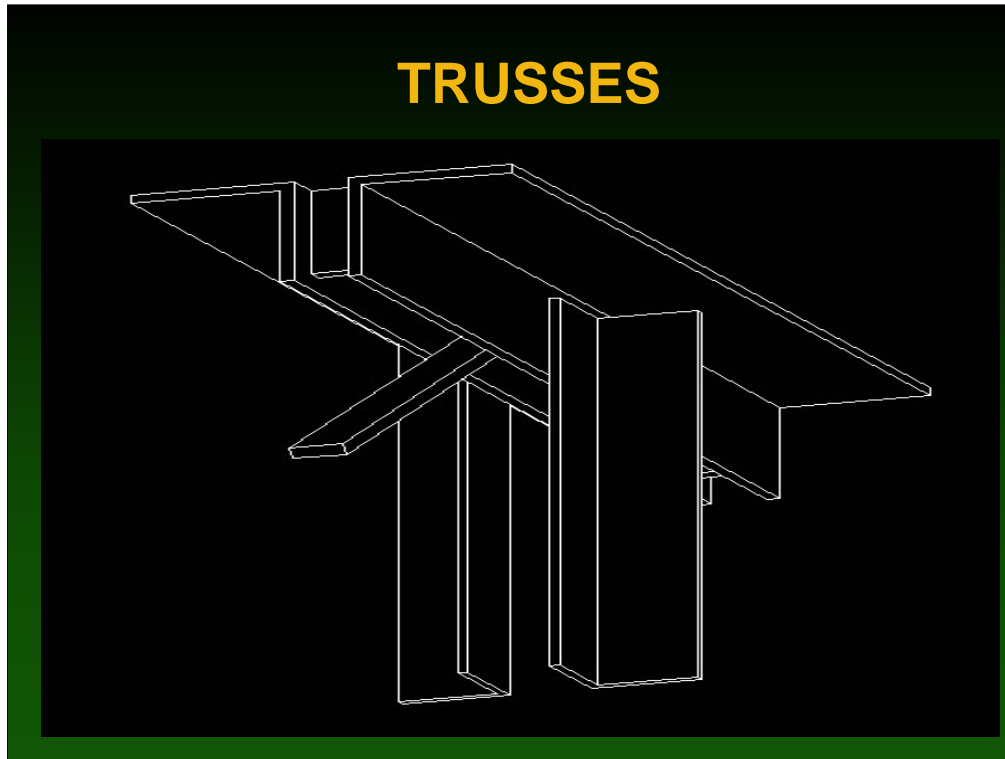
One example of angles in close contact are back to back bracing angles. They can be either welded or bolted to each other with or without spacers.

The use of double angle headers is quite common. If a multi coat paint system is specified difficulties are encountered when painting between the angles. We try to double bolt these joints to avoid the problem.

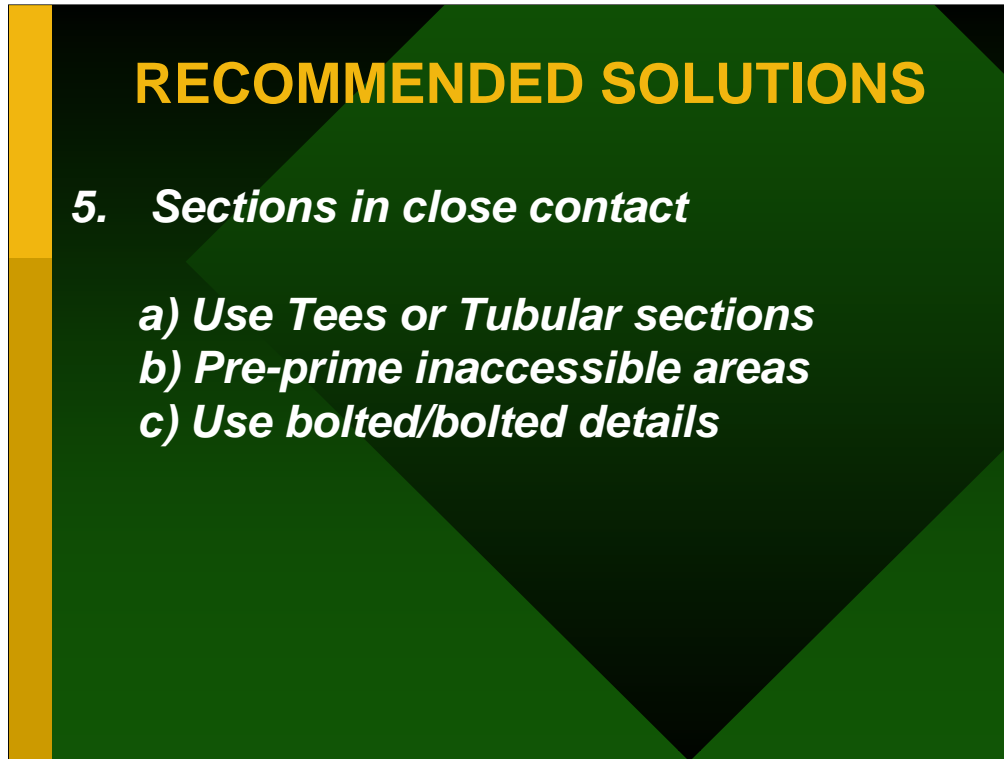
Seat angles are not as critical because they form a bearing seat that can be adequately painted.

Girt clips come in contact with the support and often project beyond the face of the support. As a result there are several locations into which moisture can seep.

In trusses, especially joists, the chords are usually within 1 to 1 1/2' apart. Access to these joints is therefore restricted. Care must be taken to clean these joints thoroughly and ensure that the paint gets into all of the crevices.



Double angle trusses with the web members welded between the angles limits the access to interior surfaces. These type of trusses should be avoided in multi-coated paint systems as proper coverage is extremely difficult.

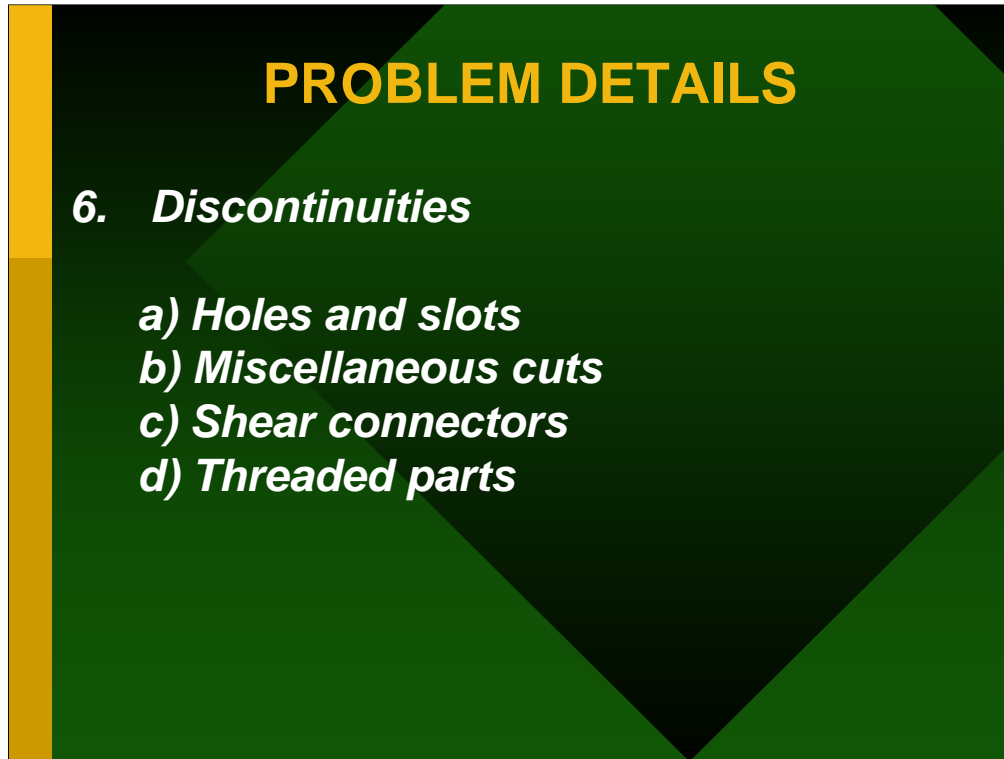


Good detailing practice can reduce the problems with double angle details.

Often the simplest solution to eliminating the back to back angle risk is to replace the angles with a tee. Detailers can recommend this at the detailing stage if it hasn't already been done. Designers need to consider this more frequently at the design stage. If tubes are used care must be taken to close the ends of the tubes to avoid corrosion of the interior of the tube. Vent holes should be provided especially on members subjected to extreme temperature ranges.

If the detail cannot be eliminated then ensure that cleaning and priming of the surfaces in close contact are done prior to final assembly. This will ensure that the joints will not corrode.

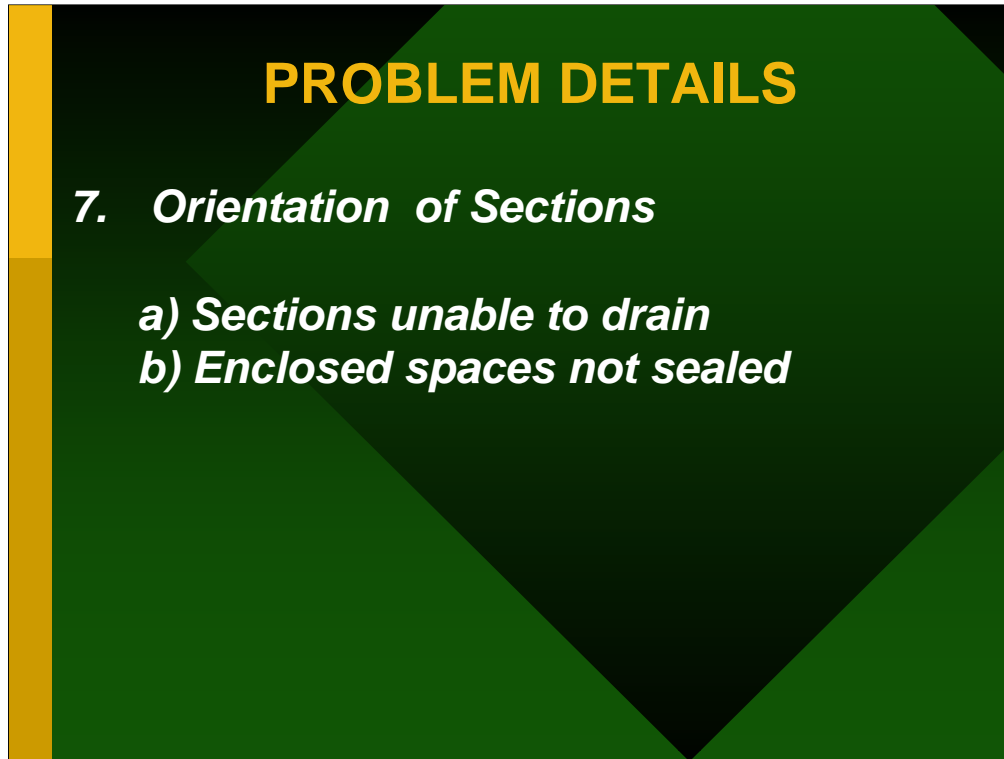
Using bolted/ bolted details creates quite a number of additional pieces that have to be handled by both the shop and the field. It does, however, allow you to paint each piece individually to ensure adequate coating coverage to avoid corrosion issues. In these cases it would be best to use bearing bolt conditions to avoid the masking required for pre-tensioned, slip critical, joints. Designers need to satisfy themselves that slip is actually detrimental to the overall structural performance.



I consider any detail that can create a crevice for corrosion products to collect a discontinuity. Holes and slots create crevices into which corrosive products can seep. Any cut will create rough edges which will require grinding to remove burrs. Shear connectors applied through the deck to the top flange of beams will not fuse properly if the top flange has been painted. The lack of paint between the deck and beam top flange if the steel has been masked creates an opportunity for corrosion in aggressive environments. Threaded parts have numerous sharp edges that require the fabricators attention to ensure that corrosion does not start at these locations.



What can be done to reduce the risk of these type of details? Bolt holes need to be stripe painted to ensure that all the surfaces of the hole get proper paint coverage. This is especially important if snug tight bolted joints are used since moisture can get into these joints. Detailers must ensure that slotted holes have proper washers to cover the slots so that moisture cannot collect in these locations. Consider using plated bolts in highly corrosive joints. If they are not specified get the consultant to review the criteria as this will lower the risk of a corrosion failure. Ensure that all burrs and edges are removed by grinding as already discussed previously.



Many sections are installed with sections orientated in such a way that standing moisture can collect on the surfaces. Due to the sag in members some section can become a trap for moisture. Channels with toes detailed up are the most common occurrence of this problem. Beams installed with webs horizontal also suffer from this condition. Sections are often boxed for structural reasons. These sections can collect water if care isn't taken to seal the space. Corrosion will occur in these enclosed spaces without knowledge of the designer.

RECOMMENDED SOLUTIONS

7. *Orientation of Sections*

- a) Detail sections with webs vertical***
- b) Provide slope for drainage***
- c) Add drain holes***

With some care and attention orientation problems can be overcome. Beams and channels should be orientated with the webs vertical so that water cannot collect and stand for any period of time. Exposed steel on which moisture can collect should be detailed with a slope to ensure drainage. Drain holes should be added if you know the section cannot be orientated or sloped to drain.



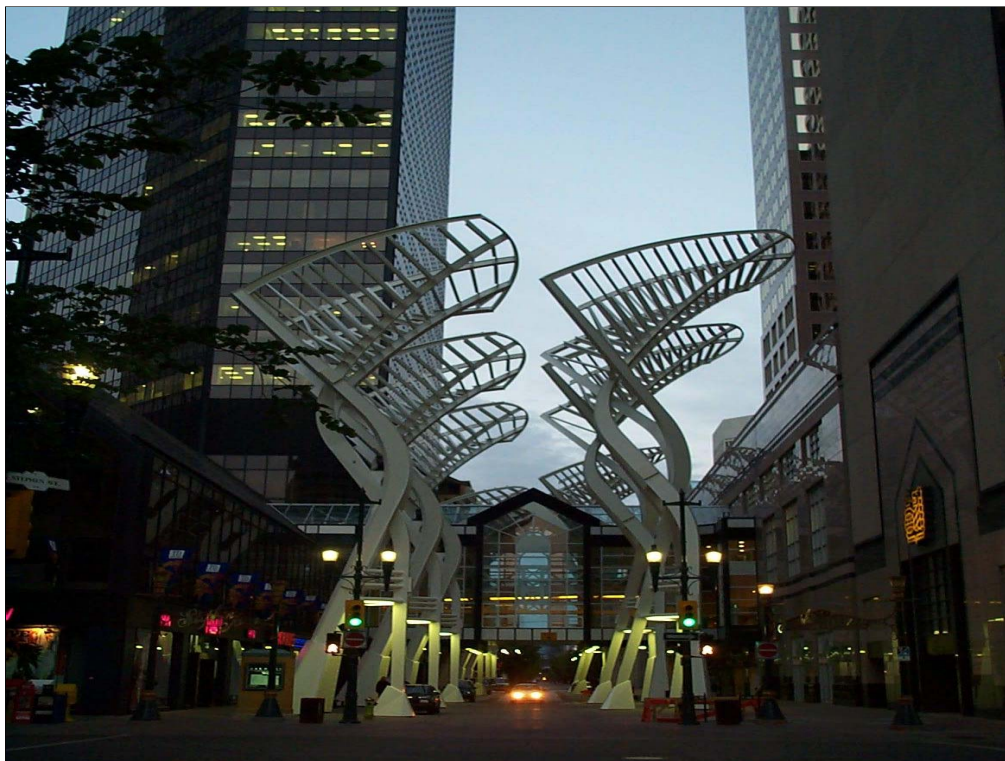
CONCLUSION

- 1. Poor design details will contribute to coating failures regardless of the quality of paint.*
- 2. The effect of poor details can be minimized with good detailing and painting practice.*
- 3. The life of the system can be improved by using good fabrication practice.*

Regardless of the quality of the paint corrosion will occur if inadequate attention is paid to details. Special attention needs to be paid to edges, welds, corners, discontinuities, sections in close contact and the orientation of members so that corrosion is prevented. Designers and detailers have the power to recognize these conditions and design accordingly. Specifications and shop notes should reflect the degree of care required to ensure that the steel is finished to provide acceptable conditions for the application of paint.

It has been demonstrated today that there are numerous projects with poor details that have performed adequately. This is because fabricator ensured that these projects have been properly cleaned, edges ground, closed boxes properly sealed, stripe painted and finish coated. The judicious use of pre-cleaning, priming and caulking was enough to ensure long term performance of the coating.

Fabricators can ensure that exposed structures perform well over the long term by employing good fabrication practices such as controlling weld profiles, grinding rough welds, eliminating undercut, seal welding exposed joints, pre-priming inaccessible surfaces, pre-priming areas that may see the incursion of moisture, and caulking intermittently welded joints subjected to wetting conditions.



Thank you for your attention. I will be glad to answer any questions that you have.