Steel Unitized Structures Technologies And Repair

Video Scripts

I-CAR®

OPENING THE CLASS

B-6v Video: Topics Off Limits
It's important that we avoid topics which create a conflict with anti-trust laws and the combines act. Therefore, we will not talk about labor rates, parts or equipment prices, repair times, cost and profit margins, dividing up the market between customers and suppliers, a boycott or refusal to deal with anyone, judgement on the work of a specific shop or practices of a specific insurance company, policies and guidelines for settling claims, or how a shop or company conducts its business.

These topics have nothing to do with repair technology. So there is no need to discuss them in class. If they are brought up in class, the conversation will be stopped.

MODULE 1–STEEL STRENGTH AND UNITIZED STRUCTURES REPAIR

B-19v Video: Brittleness Of Ultra-High Strength Steel

For this demonstration, we will use one boron-alloyed steel coupon and a mild steel coupon. The top half of the coupons are secured together and bent back and forth. After the seventh bend the boron-alloyed steel coupon breaks.

It takes 13 more bends before the mild steel coupon breaks. Although the tensile strength of the boron-alloyed steel is 160,000 psi, it is more sensitive to cracking than the mild steel that only has a tensile strength of 40,000 psi.

C-3 Demonstration: Yield-To-Tensile Strength Ratio

For this demonstration, we will use a paper clip and a toothpick to demonstrate the difference between a material with a low yield-to-tensile strength ratio and one with a high yield-to-tensile strength ratio. The paper clip is made of a low-strength steel that has a low yield-to-tensile strength ratio. Because of this, it can be easily bent in the plastic deformation range where it maintains a new shape without cracking.

The wood that the toothpick is made from has a high yield-to-tensile strength ratio. When we attempt to bend it in the plastic deformation range and get it to maintain a new shape, it cracks instead.

C-4 Demonstration: Work Hardening

For this demonstration, we will use the paper clip we used earlier to show the affects of work hardening on steel. As the paper clip is bent back and forth, it work hardens at the point of the bend. This makes the steel in the area of the bend stronger, but also more brittle as the yield-to-tensile strength ratio is also increased. After repeated bending back and forth, the brittleness of the steel increases to the point that it breaks where it was being bent.

C-7v Video: Straightening High-Strength Steel Structures

The high-strength steel left front frame rail on this Honda Accord is damaged beyond repair and requires replacement. Before the rail can be replaced, the structure of the vehicle has to be returned to its dimensional specifications. Let's see how the use of higher-strength steel in the structure affects this process.

We will be using a fixture bench in order to take advantage of the added anchoring for straightening and positioning of the new frame rail for welding. First the front bumper cover, hood, left fender, left headlamp, and front bumper reinforcement are removed. The drivetrain and front suspension will also be removed to allow access to the rail spot welds and to mount the vehicle to the straightening bench fixtures. Before this can be done, the fuel pressure is released by removing the fuel pump fuse and the fuel cap and then starting the engine and letting it run until it stalls to remove the fuel from the lines. The battery is then disconnected and the fuel lines are disconnected. Notice that a rag is used to catch any fuel that may leak out after disconnecting the line.

After draining the coolant, the radiator and fan assembly is removed. Next, a refrigerant recovery machine is used to recover the air conditioning refrigerant, and the air conditioning condenser is removed. Then, the air conditioning lines and radiator hoses are capped to keep contaminants out. Next, the technician removes the battery, air cleaner assembly, and under hood fuse box. Notice that that electrical connector ends are covered to prevent contamination during repairs. Next, the air intake tube is removed from the outside of the frame rail.

To avoid opening the hydraulic system for the brakes, the front calipers are unbolted and tied up out of the way. The upper control arms are separated from the wishbone-style steering knuckles. After the vehicle is lowered to place the drivetrain and suspension subframe on a pallet, the oil cooler and air conditioning refrigerant lines are disconnected. Next, any additional lines and wiring that require it are disconnected. The right upper motor mount to the frame rail is disconnected, and the subframe bolts are removed. The vehicle is raised on the hoist, leaving the subframe and drivetrain on the ground. Next, the front struts and upper control arms are removed from the vehicle. Any remaining brackets or parts attached to the damaged rail are removed.

The vehicle is loaded on the straightening bench and bolted to the four center section fixtures. Using the data sheet from the equipment maker, additional fixtures are assembled to the machine and vehicle for measuring and straightening purposes. The driver seat is removed so that the carpeting can be pulled back out of the way to access where the frame rail attaches to the cowl and floor. The pulling post is attached and a section of the radiator core support is cut away to allow access to the front of the frame rail with a clamp. After attaching the pulling clamp, an initial pull is made to bring the entire front structure closer to specification. Notice that the damaged areas are stress relieved while the pull is still under tension. Because of the higher strength of the structural parts, too much pressure is required on one pull to move the entire structure, so the radiator core support is cut through the center to allow each rail to be positioned individually.

Fixtures have been bolted to the right front frame rail where they line up and as the rail is pulled into position, more fixtures are connected working from the back forward. With the lower rail positioned and secured in place, a shock tower fixture is assembled to check the positioning of the right shock tower.

The left front frame rail is up and back, even at points by the cowl, so it is pulled forward and down from the front. Notice that the rail is stress-relieved as it is pulled. This helps lessen the pressure required to move it into position. The rail had been pushed back into the cowl and floor. With pressure on the pull, these areas are also stress relieved. Doing this helps ensure that the cowl will be in the proper position when the new frame rail is installed. As the rail is pulled, fixtures are aligned and bolted in place starting at the back working forward. Once the fixture points on the back half of the rail and the shock tower are aligned, the pulling is complete and the rail can be removed. Because of the strength of the rail, the extent of damage, and the fact that the rail will be replaced, we will not attempt to put the front fixture points into position, as doing this would likely cause collateral damage to other parts of the vehicle.

D-3v Video: Heat Affect On Steel

Using a tensile strength tester and strips of metal, let’s see how heat affects both the strength and mechanical properties of different types of steel. Each type of steel will be tested a number of different ways. The first sample is a baseline for the steel, a second is heated to a dull red with an induction heater and allowed to air cool. The third sample is heated and quenched in water. Next, a sample is made by cutting a strip in half and GMA (MIG) butt welding it back together. The last two samples are heated to a cherry red with a torch. One is allowed to cool naturally, and the other is quenched in water.

First, let's take a look at some mild steel samples. Notice that when this mild steel baseline sample is pulled, that the sample begins to neck and the force numbers slowly fall off from the peak of 2,126 psi until the sample breaks violently at about 1,000 psi. Watch what happens to the mild steel sample that was heated to a dull red and allowed to air cool. The peak tensile strength actually increases to 2,312 psi, and then falls off slowly to 1,000 psi where it breaks apart with a snap. Now let’s see what happens to the sample that was heated and quenched. The peak tensile strength is 2,371 psi, which is higher than the air-cooled sample. But after reaching this peak, the necking of the sample is visibly greater and the force numbers fall off 33 percent faster then the other samples. The sample softly breaks when the force is only 120 psi. This illustrates that even though the ultimate tensile strength of the sample was increased, that the mechanical properties of the steel were changed dramatically.

When the sample that was butt welded is tested, the results are even more dramatic. The heat from the welding is much greater than what the steel was subjected to when it was heated to a dull red. This results in a reduction in the peak tensile strength to 1,869 psi. But notice what happens after this peak is reached. The force numbers fall off even faster than they did for the quenched sample, 56 percent faster than the baseline, and is only 45 psi when the sample finally breaks. Notice that the sample exhibited very little necking as the heat affect zone from welding is much narrower than the area that was heated with the induction heater. When the entire sample is heated cherry red with a torch and allowed to air cool, the ultimate tensile strength is the highest seen yet at 2,395 psi and the sample stretches for 18 seconds afterwards as the force slowly falls off to 1,900 psi where the sample breaks. The sample that was heated cherry red and quenched, dramatically shows the effect of high heat and quick cooling as the ultimate tensile strength is 3,288 psi, about one-third more than the baseline sample. The mechanical properties are also drastically changed as the sample exhibits very little necking and breaks in less than 7 seconds at a strength of 2,715 psi.

Let's see what happens when we heat a piece of DP590 steel. The baseline sample reaches an ultimate tensile strength of 3,049 psi and exhibits fair ductility as it stretches for 7 seconds before breaking at 2,564 psi. When we test the DP590 sample that was heated with the induction heater and air-cooled, the ultimate tensile strength only decreases slightly to 2,785 psi. However, notice that the ductility has been changed dramatically as the sample only stretches for about half the time of the baseline and breaks at 1,697 psi. Now watch what happens to the DP590 sample that was heated cherry red and quenched. The ultimate tensile strength increases over 60 percent to 5,061 psi and the sample stretches for less time than the baseline breaking at 4,040 psi, indicating a loss of ductility compared to the baseline sample. This metal would no longer be able to absorb the collision energy that it was intended to and would instead transfer the energy rearward.

Now let's run a series of tests on strips of boron-alloyed steel. As with the mild steel, one sample is the baseline, one is heated to a dull red with an induction heater and air cooled, one heated to a dull red and quenched, and one cut apart and butt welded. Because of the increased strength of the boron-alloyed steel, the samples used for it are half of the cross section of the mild steel samples. The peak tensile strength reached is 4,625 psi. After this is reached, the sample exhibits no visible necking and it takes less than one second for the sample to break very violently. This shows that the steel is very strong and brittle, has very little ductility, and a very low total elongation percentage.

Watch what happens when we pull the boron-alloyed steel sample that was heated to a dull red and air-cooled. The peak tensile strength goes down almost 50 percent to 2,430 psi, showing the dramatic affect of even a few seconds of low heat on this type of steel. Notice also that after the peak is reached that the sample exhibits visible necking and the force number drops for over 5 seconds to 2,057 psi where the sample breaks. This indicates that the heat also had a dramatic affect on the mechanical properties of the steel, such as total elongation and ductility, as well as the strength. Let’s see what happens to the boron-alloyed sample that was heated and quenched. The peak tensile strength increases from that of the air-cooled sample to 3,106 psi. However, this is still a 33 percent reduction from the baseline sample. And notice what happens after the peak is reached. The sample shows no visible necking and violently breaks at 2,762 psi, less than 1 second later. This shows how quenching a heated steel increases the brittleness when compared to allowing it to air cool.

Now let's see what the additional heat from welding does to the boron-alloyed sample. While the peak tensile strength is the lowest of any of the samples at 2,400 psi, it is not significantly lower than the sample that was heated to a dull red, showing that even moderate heat is as damaging as extreme heat on boron-alloyed steel. Notice also that after the peak is reached that the sample shows no visible necking and that it breaks in less than a second at about 2,374 psi, indicating less change in the mechanical properties than with the quenched sample.

F-18v Video: Sectioning Boron-Alloyed Parts

With a section of the outer body panel on this 2003 Volvo XC90 removed, the inner portion, which is made from UHSS alloyed with boron, can now be accessed for removal.

Make a template using masking tape so the exact cut line can be transferred to the replacement part. Make measurements to a reference hole beyond the sectioning joint to ensure proper panel placement during fit-up. Mark the cut line, remove the template, and transfer to the replacement part.

Drill out spot welds using a pneumatic C-clamp style spot weld drill. Drill out the spot welds on areas that are accessible. Since this is UHSS alloyed with boron, use the bit designed for use on this material. On areas that are not accessible with the spot weld drill, a plasma-arc cutter, which can be adjusted for depth of cut, may be used. To use a plasma-arc cutter, make a circular cut around each spot weld, being careful not to cut all the way through the inner panel. Practice should be done on a scrapped part before attempting to use this method. Use a cutoff wheel to cut the damaged part. After the cut has been made, use an air chisel to separate the flanges of the damaged part and remove the damaged part from the vehicle.

Next, cut the replacement part at the cut line. Clean the flange on the existing panel by removing any remaining seam sealer and grinding down nuggets from the factory spot welds. Smooth the cut edges on the remaining section of the outer lower rear body panel. Temporarily install the replacement part on the vehicle and check for proper fit-up. Remove the E-coat from the weld zones on the existing panels. Mark the plug weld locations and drill the plug weld holes in the replacement part. Since this part is made from ultra-high-strength steel alloyed with boron, the pneumatic C-clamp style spot weld drill is recommended using the hard drill bit. The depth of the cut is adjusted so the drill bit goes all the way through the part. A steel coupon should be placed on the backside of the part to prevent damage to the anvil on the drill.

Remove the E-coat from the weld zones on the replacement part. Apply weld-through primer to the bare metal areas on the replacement part and the existing parts. Apply a sprayable seam sealer to the mating flange on the bottom flange. Use a brush to ensure all of the bare metal is covered. Install the replacement part and clamp it into the proper position. Use a GMA (MIG) welder to weld the seam at the sectioning joint. Volvo recommends starting in the middle of the weld seam and making small stitch welds, allowing the weld zone to cool between each weld. This reduces the heat-affect area. Make GMA (MIG) plug welds after the sectioning joint is complete.

Identify the location of each resistance spot weld. Volvo recommends replacing spot welds one-for-one to the original number of spot welds and positioning them as close to the original location as possible without being in the exact location as the original weld. In this case, the damaged part is used as a reference. Make resistance spot welds on the bottom flange. After the welding is complete, dress the GMA (MIG) welds using a grinding disc, and prime with epoxy primer. The upper rear body panel can now be installed.

MODULE 2–NEW CONSTRUCTION PROCESSES

B-8v Video: Rivet Bonding To Laminated Steel

This General Motors vehicle has a laminated steel cowl panel. When replacing the front lower rail, the area of the rail that is attached to the cowl panel is secured by rivet bonding. Let's see how the lower rail is fastened to the laminated steel.

For this vehicle, the service procedure and rivets are supplied with the service part. To make the repair process more visible, this body-in-white will be used. To begin, both the upper and lower radiator core support and aprons are removed to gain access to the lower rail. The original spot welds connecting the lower rail to the laminated steel cowl panel are removed using a 7 mm spot weld drill. The welds are removed by drilling through the rail flange only. Care is taken to prevent drilling into the cowl panel. After locating and removing the remaining factory welds, remove the rail from the vehicle.

The reattachment area on the vehicle is prepared for the replacement part by removing any remaining adhesive. Next, the replacement part is temporarily installed while fixtures are used to hold the rail in position. A computerized three-dimensional measuring system is used to position the replacement rail, ensuring that it is installed in the proper location. Using the damaged part as a reference, the exact number and locations of attachment holes should be duplicated. The rivet attachment locations are made by drilling 7 mm holes through the rail flange and the cowl panel. The service part is then removed in preparation for final installation.

Before applying the adhesive, the bonding areas are cleaned to bare metal and wax and grease remover is used to clean contaminants from the surface. A 3–6 mm bead of metal panel bonding adhesive is applied and spread across the mating surfaces with a clean acid brush. All bare metal should be completely covered to ensure proper corrosion protection. Apply a second bead of adhesive to the service rail to ensure bond-line thickness.

The replacement rail is now ready for installation. It is important not to remove the rail from the cowl panel after contact with the adhesive. Removal may cause air pockets in the adhesive. Any repositioning should only be done by sliding the rail. After the three-dimensional location of the rail is verified, it is clamped into place and riveted to the cowl panel. According to the service procedure, the horizontal rivets should be installed from inside the passenger compartment so that the rivet heads contact the inside of the cowl panel. Any excess adhesive is removed from the rivet-bonded areas of the rail.

E-9v Video: Layered B-Pillar Replacement

Using this Buick Enclave body shell, let's see a procedure for replacing a B-pillar that is layered underneath the structure of the roof.

The vehicle maker has a sectioning procedure to avoid having to remove the roof when replacing the B-pillar reinforcement assembly. The first step in the repair is to remove the outer B-pillar. The procedure shows measuring 93 mm down from the top of the B-pillar and marking a cut line. The lower part of the B-pillar can be removed by making sectioning cuts based on personal preference or outer rocker panel damage in the door openings. Cut lines are marked with tape and a pneumatic reciprocating saw is used to make the cuts. Care is used to ensure that the cuts do not damage any inner panels or reinforcements. Next, a spot weld drill is used to remove the spot welds from the flanges of the outer B-pillar. The depth of the drill is set so that it only drills through the weld on the outer panel. Additional spot welds are removed from the areas where the door hinges bolt to the vehicle and where the outer rocker is attached to inner reinforcements. An air chisel is used to carefully separate the outer B-pillar from the vehicle. A sharp putty knife is used to separate the lower part of the B-pillar from the NVH foam that is installed there and the outer B-pillar is removed from the vehicle, exposing the inner reinforcement assembly.

The service procedure calls for a sectioning cut to be made 20 mm below the bottom of the oval hole exposed at the top of the B-pillar reinforcement. The cut line is marked with tape and the B-pillar reinforcement is cut with a cut-off wheel. A spot weld drill is used to drill through the welds along the flanges. There are two ultra-high-strength reinforcements that are spot welded up the length of the B-pillar reinforcement assembly. They continue beyond where the sectioning cut was made, so the spot welds attaching the reinforcements to the portion of the B-pillar assembly that will remain, are drilled through. An air chisel is used to carefully separate the reinforcement assembly from the vehicle. Once completely separated, it is removed from the vehicle. Next, the remaining pieces of the ultra-high-strength reinforcements are removed from the upper portion of the reinforcement assembly remaining on the vehicle. The plate shown here is supplied already attached to the new B-pillar reinforcement assembly, so the spot welds attaching it are drilled out and the plate is removed from the vehicle.

A small grinder is used to remove any remaining weld nuggets from the inner B-pillar and rocker panel inner reinforcement. Next, a plastic abrasive brush is used to remove the foam sealer from the rocker panel reinforcement. Weld-through primer is applied to all bare metal mating flanges and surfaces. The service part is supplied pre-cut so it is clamped into position for a test fit. Notice that the ultra-high-strength steel reinforcement fingers are slid up into the part of the reinforcement assembly that remains on the vehicle. With the part clamped in place, three-dimensional and comparative measuring is used to verify proper positioning of the part. Plug weld locations are marked on the part and it is removed to prepare it for welding.

The coatings are removed from the part in the plug weld areas and on the vehicle where necessary. Following the vehicle maker's recommendation, weld-through primer is applied to all bare metal in the mating flanges and sectioning locations on the vehicle and service part. The part is then repositioned on the vehicle, clamped in place, and rechecked for fit with the three-dimensional measuring.

Practice welds are made and destructively tested before welding on the vehicle. GMA (MIG) plug welds are made through the holes drilled in the existing part of the reinforcement assembly and into the ultra-high-strength reinforcement fingers on the top of the service part. The sectioning joint is welded solid using 25 mm stitch welds to lessen the heat input. The bottom of the reinforcement assembly is attached to the rocker panel reinforcement using GMA (MIG) plug welds. A plastic abrasive brush is used to remove the weld-through primer from the immediate weld zone. After making practice welds to verify the correct settings, the plug welds are made on the vehicle.

Spot weld locations are marked next to the original weld locations on the flanges of the part and the plastic abrasive brush is used to remove coatings from these locations on both the replacement part and the vehicle. An inverter type squeeze-type resistance welder is used to make the spot welds for the reinforcement assembly.

Next, the plug welds and stitch welds at the sectioning joint are dressed. Weld-through primer is applied to any bare metal on the mating flanges where the outer B-pillar will be welded and corrosion resistant epoxy primer is applied to the sectioning joint before it is covered with the outer B-pillar.

To complete the repair, the outer B-pillar service part is cut and prepared for welding, as are the flanges on the vehicle. NVH foam is installed in the areas where it was removed. Next, the outer B-pillar is clamped in place and welded using butt joint with backing welds at the sectioning joints. Plug welds are made along the middle of the rocker panel and spot welds at the remaining flanges. The sectioning joint is prepared for priming and refinishing, and the application of corrosion protection materials will finish the repair.

G-3v Video: Weld Bonding

We will use this inner aperture replacement part, and install the outer side aperture replacement part using weld bonding.

The adhesive maker recommends removing all of the coatings, including the zinc coating, from the mating flanges on both the inner and outer aperture portion. The bare metal will be covered by the corrosion-resistant adhesive. Before dispensing the adhesive, the plungers are leveled by dispensing a small amount into a shop towel. Cartridge caps are removed, the mixing tip is installed, and a short length of adhesive is dispensed on a mixing board, about the length of the mixing tip. Adhesive is applied to the mating flanges on both apertures and spread out to ensure all of the bare metal is covered. A smaller diameter, third bead of adhesive is applied to the inner flange that would be on the vehicle. This helps ensure proper bond-line thickness. The outer panel is fit-up. After the part comes in contact with the adhesive, it should not be lifted off. This may cause air pockets in the adhesive. If alignment is necessary, the part should be slid into proper position.

The instructions for the acrylic adhesive that is being used recommends that spot welding can be done either while the adhesive is still wet or after the adhesive has cured. We will first show spot welding after the adhesive has cured, which is more difficult than if the adhesive is still wet.

Typically, there are glass beads in the adhesive that help ensure proper bond-line thickness. We can show more clearly on this test sample, which should be made at the same time the vehicle is fit-up. A close look at the edge of the test sample shows the thin bond-line thickness. The adhesive is allowed to cure so the clamps can be removed. The decision is to remove the E-coat along the entire outer flange on the outer aperture, since it is unknown exactly where the replacement spot welds will be made. The original spot weld sites are visible on the inner aperture, so E-coat on the outer flange on the inner aperture will be removed just in the spots where the replacement spot welds will be made.

The first spot weld is made using a shunt clamp. A shunt clamp is recommended for weld bonding rather than a regular locking pliers. The shunt clamp has a heavy gauge copper wire between the clamping pads, whereas arcing could occur across the rivet on a locking pliers. The remainder of the welds are made without a shunt clamp. Note the double sound with each weld. Although not necessary for weld bonding, this particular welder has a weld-bond setting that makes an initial, lower current weld before making a second, higher current weld. The intention is to burn through the adhesive with the first weld, opening the way for the second weld.

The technician refers to the inner flange to avoid the original weld locations. After making the spot welds, the adhesive should be encapsulated around each spot weld. One sign of this being successful is when looking at the joint edge, there should be no signs of adhesive blowing out of the joint. This sample shows a successful weld bond after peeling. The adhesive is encapsulating the spot weld. On this sample, the adhesive was blown out of the joint. The spot weld is no longer encapsulated by the adhesive.

To show weld bonding when the adhesive is still wet, we will use this partial inner aperture and a simulated outer panel. The technician makes a test weld on three thicknesses of coupons, also with the adhesive wet. The shunt clamp is installed on the test coupons. The test weld is made. With the welder adjusted to the correct settings, the simulated outer panel is fit-up, starting with the shunt clamp at the first weld site. Other clamps required for fit-up are insulated with tape so current is not shunted through the clamps. The first weld is made near the shunt clamp. Other welds are made in succession, each weld shunting through the previous weld. When the fit-up clamp is reached, it is removed. Note that the technician uses the backside of the panel, where the original welds can be seen, to locate each spot weld. A spot weld is also made at the site of the shunt clamp. The technician removes the excess adhesive, all along the joint.

Ford Motor Company has developed bulletins describing the process of weld bonding with spot welds and weld bonding with GMA (MIG) plug welds where spot welding arm sets cannot reach. Let's see how this is done. The panel on this F-150 is being installed with weld bonding. The plug weld locations are marked to help guide the technician because adhesive should not be applied in the GMA (MIG) weld zone. Ford also recommends maintaining the same spacing and number of spot welds. Plug weld holes are made. Test coupons are welded together. In this case, the welds will be made through wet adhesive, so that is the way the sample is tested. The size of the nugget is measured, and compared with the chart in the weld bonding bulletin. The front edge of this part requires GMA (MIG) weld bonding. The bulletin states to place 25 millimeter tape over the plug weld holes to prevent adhesive from getting in the weld location. After applying the adhesive, the tape is removed and the replacement part is installed on the vehicle. Spot welds are made in all of the areas that can be accessed with the equipment. GMA (MIG) plug welds are made in the other areas.