NPTEL Online Certification Courses
Industrial Robotics: Theories for Implementation
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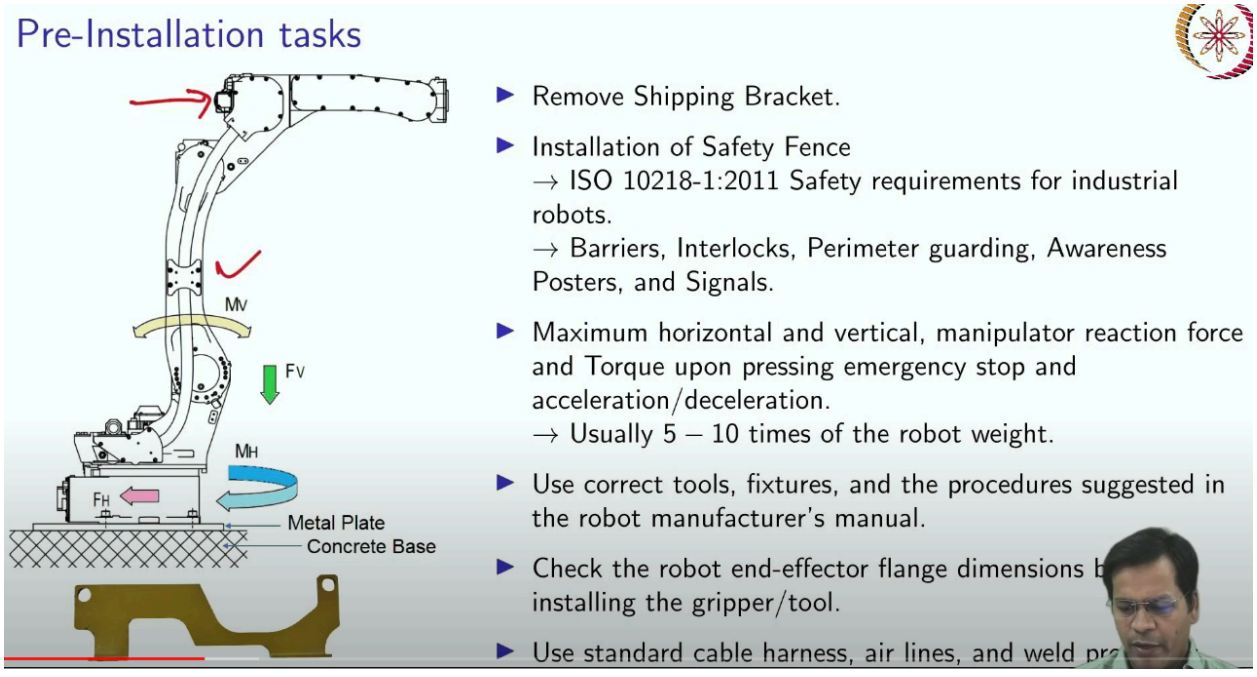
Lecture: 26

Installing the Mechanical Arm and Test Run

Welcome back. So, with the previous modules that we have covered, we are now familiar with industrial robots, technical specifications, and forward and inverse kinematics of such robots. So, with that, we are technically now ready to start learning something very, very practical right from the beginning when these robots are installed in industrial software; not just an industry, quite a lot of universities also nowadays have industrial robots in their lab. To begin with, I will start with a very low payload capacity robot of something around 10 to 15 kg payload capacity, which is quite good for doing pick and place kinds of robotic jobs, welding jobs, and painting jobs. So, small scale jobs can be taken up by such robots.



So, in today's lecture, I will be just discussing the installation and commissioning of one such robot. Pre-installation tasks are a few tasks which are required before the installation of these robots on any floor. So, we will just start with that so, when a robot is delivered after long transportation from a foreign country or maybe from the manufacturing side. They come very much like in a collapsed form, something like this, which is known as the transport state of this

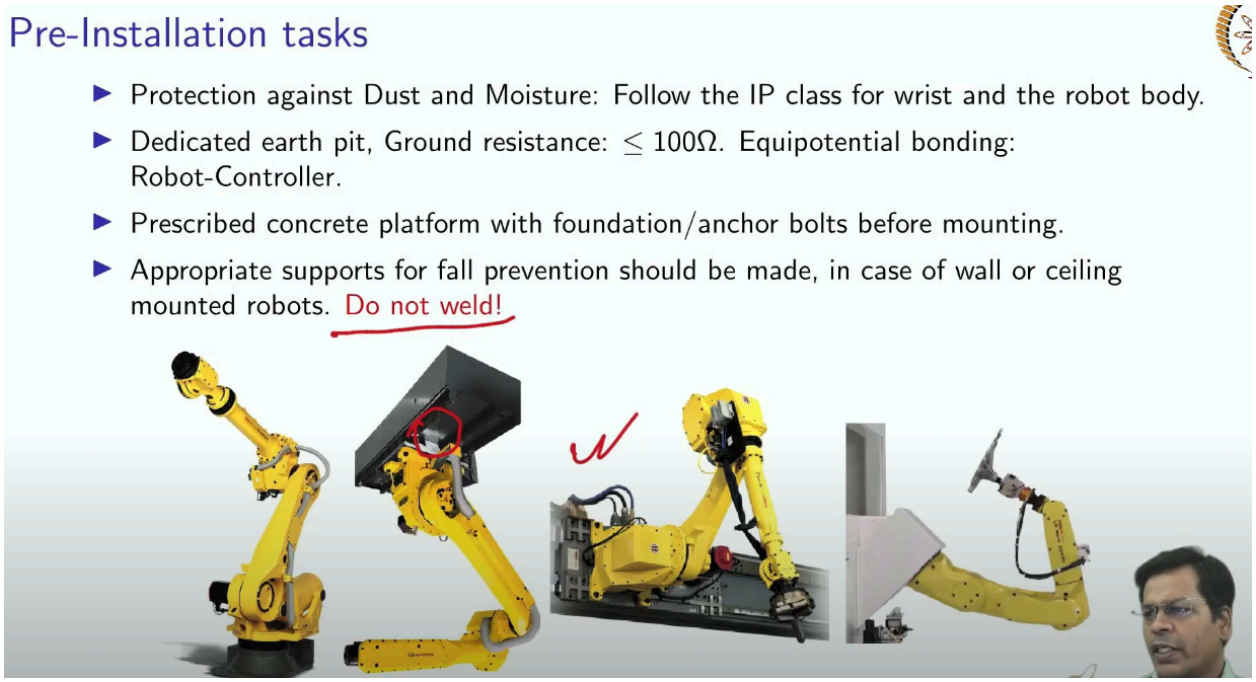
robot, or home state, which is our transportation state. So, in this condition, this robot has its CG, which is very much in line with its major axis, and weights are not very much distributed. It is very much focused towards the centre of this structure. So, that makes it very, very stable and easy to transport. In such a collapsed state, they can be easily put in a huge container, and apart from that, they are also fitted with a type of clamp somewhere on this robot or maybe a mounting frame which is there so that you can hold it, lift it and transport it during the transportation. This is one such part which is fitted in the Yaskawa GP-12 robot, the one that we have recently installed in our lab. So, this is a mounting bracket which is there. So, it goes to the robot somewhere over here. It is bolted to the robot, and it comes something at this region. In this region, it is there. I will show you the actual picture and the videos that actually show this particular part fitted on top of the robot, which was later removed. So, yes, this is how it looks. It is just a skeletal picture of such a robot.

So, let's start. So, we will just have to remove such a shipping bracket because now that it has come to our site, we will have to remove it so that even by mistake, we should not start the robot moving. So, that is why this is to be removed. So, all major transportation is now over. It can be lifted using just small shackles which are there. So, apart from that, the installation of a safety fence is very, very important at the manufacturing site. It is the requirement of ISO 10218-1:2011, that is, a safety requirement for industrial robots. This is the standard that tells you that you should have a proper barrier. You can have interlocks. Interlocks are the kind of switches which are installed in the robot so that, as long as a person is there within the workspace of the robot, it may have some kind of proximity sensor, physical limit switches or door closer switches so that it comes to know that a person is there inside the work cell of this robot. It doesn't allow you to start the robot. So, that kind of interlocks are there. Perimeter guarding can be there. Perimeter guarding is something like this. I will show you in this picture also.

So, you see, you have a very good guarding which is there throughout, like a red strip which is there, although it cannot prevent a person falling inside this cage. But, yes, it is quite good enough to make you understand that from here, your work area actually started, and it is not safe to get into this area and you may have some white stickers which are there on the floor.

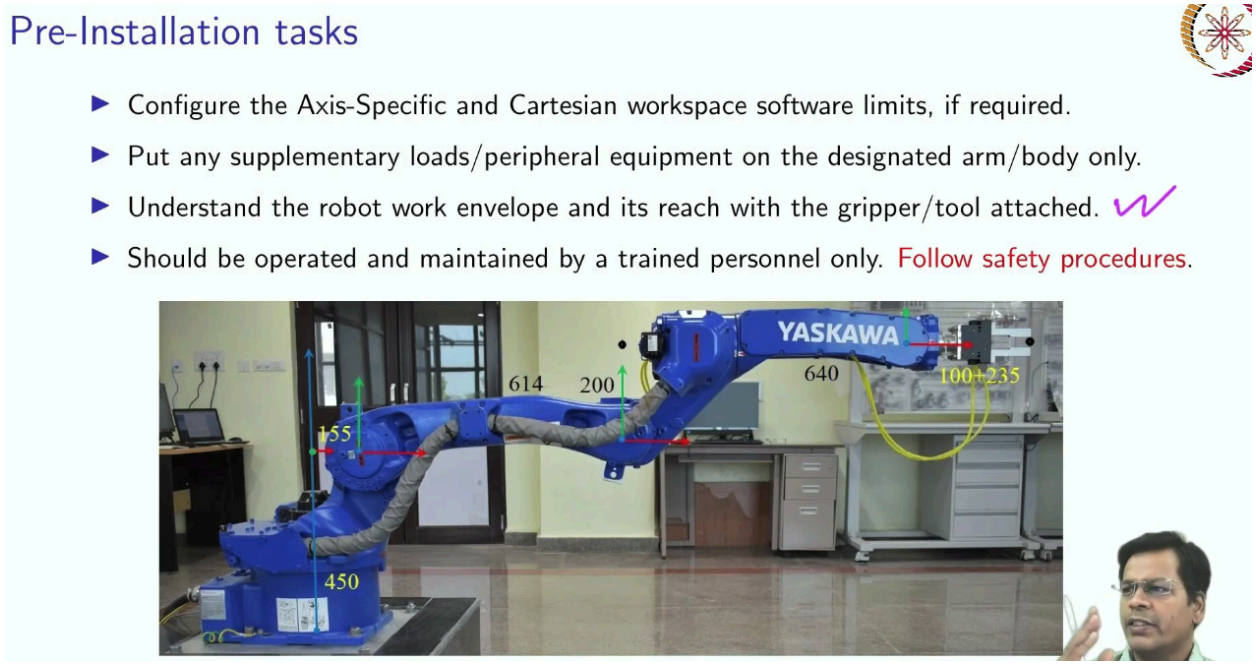
Apart from that, you can have an awareness poster all around the workspace so that people are aware that you should not enter because these robots are very much like beasts. So, you should not enter into these areas so that, yes, it can even kill you. So, they are very, very dangerous. They are powerful robots. So, there are signals as long as the robot is running. They have signals in that workspace red, green, and orange that can be switched on when required during maintenance, during operation and when it is halted. You should be very much aware, by going through its technical manual, which is provided by the manufacturer, how much the maximum horizontal and vertical manipulator reaction forces and torque can come upon pressing the emergency stop or while it is accelerating or decelerating. These are the instances when it can generate the maximum horizontal and vertical forces and torques. So, they are mentioned in the datasheet or the technical installation manual or system integrators manual of this kind of robot. So, they will precisely specify how much these values are. So, you should be careful while you design your concrete structure or wherever you are going to mount this robot.
They are usually 5 to 10 times the robot's weight. So, the use of correct tools is very, very important. You should not use some very much like the weight tools. You cannot use spanners to

handle something to hammer it. So, those precautions should be taken. Fixtures should be well planned before installation- how you will lift them, how you will align them to the boards, and how you will place them in the proper location. And the procedures are very well suggested in the robot manufacturer's manual. So, those should be gone through before installation, and you should also check the robot's end-effector flange dimension so that you can procure a proper gripper or end-effector tool. It may be a welding, it may be just a two-fingered gripper or a three-fingered gripper. It can be a painting gun welding gun, So that flange should match. We have discussed enough while we were discussing the technical specifications of these robots, and the use of cable harnesses should be done. You see, this is the cable. So, cable harnesses are provided by the robot manufacturer, also. The standard ones are the cables that are used for the robot's functioning. They are provided. So, you see, it goes here. Let's say you have fitted a welding gun, so you need to pass your welding cables and all. So, in the case of a robot like the Yaskawa GP-12, which has a centre hole, I will show you in the video that allows passing the cables through this hole. Airlines, that is, to handle the pneumatic gripper, if you have welding provisions, So all those wires can be properly harnessed so that they don't obstruct the robot while it is moving. And if it gets entangled your robot may get totally non-functional.



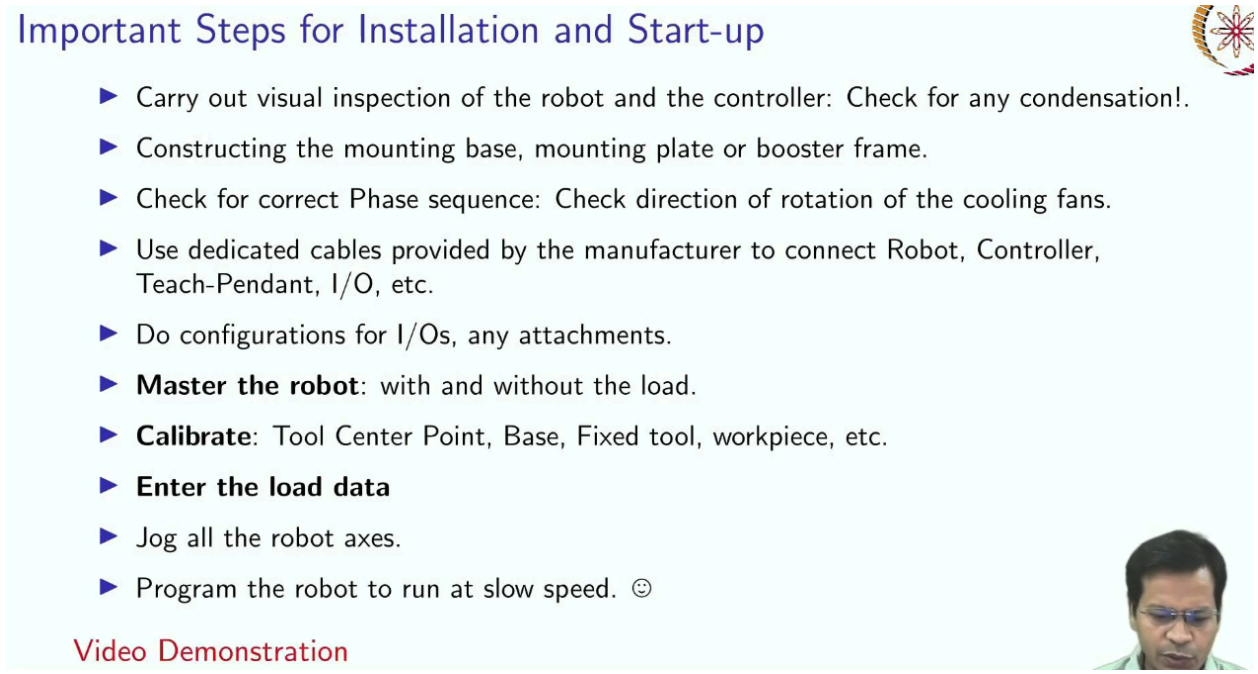
Protection against dust and moisture: You should follow the IP class that is there for the wrist and the robot body. Your wrist may have IP54 class, whereas your wrist of the body may be of a lower grade also, or maybe your IP67 or higher is there at the end effector, whereas your wrist and the rest of the body is of lower class, IP54 or something like that. So, you have to understand properly before you put them to use. Proper enclosures should be there for the rest of the robot, like the painting robot You have seen in the video. While we were introducing the robot's application, you saw that it was properly enclosed well, So it was put with a wrapper all over the

robot. A dedicated earth pit should be there because it should see proper ground with a resistance of less than 100 ohms between the robot controller and the ground. Potential and equipotential bonding should be there between the robot and the controller. So, dedicated wires are there to make them all equipotential so that the phases, the electrical signals, should go properly.
The prescribed concrete platform should be there, the platform on which it is mounted. That should be as per the guidelines which are there in the manufacturer's manual. So, I will show you the exact specifications for one such concrete platform that we have built, while I will be showing you pictures and videos of that. Then, the anchor bolts are used for the mounting. These are to be taken care of and appropriate support, if at all. It is mounted upside down. So, you see, there are some structures which are here that hold it. Even in case of, let's say, bone failure or breakage, The robot will not fall upside down. When it is upside down, even when it is inclined or on the wall, it should be taken care of and not welded. This is very, very important. Any of the robot structures or the foundations are not welded because that can cause material failures.



Configure the Axis-Specific and Cartesian-specific workspace software limits. If at all it is required. So, times your workspace, let's say your robot, can go within this workspace, some forward region or this much area. It can cover this shaded area. From here to here, it can go, if at all. If you have some object which is placed in this region, then you can make your software limit in axis one so that it can go only till here got it so that you don't hit the object, So unavoidable. Any sort of structure which is there in the robot space so can be avoided, even by mistake. You cannot program the robot to go there.
Similarly, you can have some workspace in the robot area also, where the robot cannot go. By specifying the maximum and minimum limits X min, X max, Y min, Y max, Z, min, Z max, those limits can be placed in the workspace so that the robot doesn't enter into this volume or robot can work only within that volume, and it doesn't go outside that workspace. So, these are

something which can be done, and any supplementary load or peripheral equipment which are necessary for this robot to run or do some kind of function on the designated arm or the body area, which is marked in the robot's manual also. So, only those areas are to be used. I have discussed this even while I was discussing the robot's technical specifications, so I will show you that in the figures also. So, yes, you should understand the robot work envelope. How much is the maximum reach? So, you can put the physical barrier over there, and if required, you can put dedicated sensors which can sense any human until that area, proximity switches or kind of door locks or enclosure or even the cage can be put within that area. The same is the case in the front, in the back, and the top. So, the whole of the workspace can be enclosed well, and can be taken care of well. So, understand, by looking at the datasheet, you have to include the tool that is mounted at the end also, okay, and it should be operated by the trained personnel only when following the safety procedures which are mentioned in the robot's manual.



So, there are a few important steps for installation and start-up. Okay, before you actually start the controller and make the robot new. These are a few important things that you should note. So, you should carry on a visual inspection inside the controller, on the robot and the motor, and any electrical spaces, or sometimes you should look for. Any damage that might have happened while it was in transport, and check for any condensation if it has occurred on the circuit boards which are there inside the controller. So, visual inspection helps a lot. It is not always that the robot starts, and it indicates through some kind of failure. So, it is very, very useful.

Construct the mounting base, mounting plates and the booster frame. Sometimes, robots are not just mounted on a concrete floor. If it is to be mounted quite high, so dedicated booster frames are there. Even when it is mounted inclined on the wall or the floor, this kind of booster frame is

there on which the robot can be mounted. So, my standard plates are there also, and so you that we have used. Okay, so construction of that is to be done.

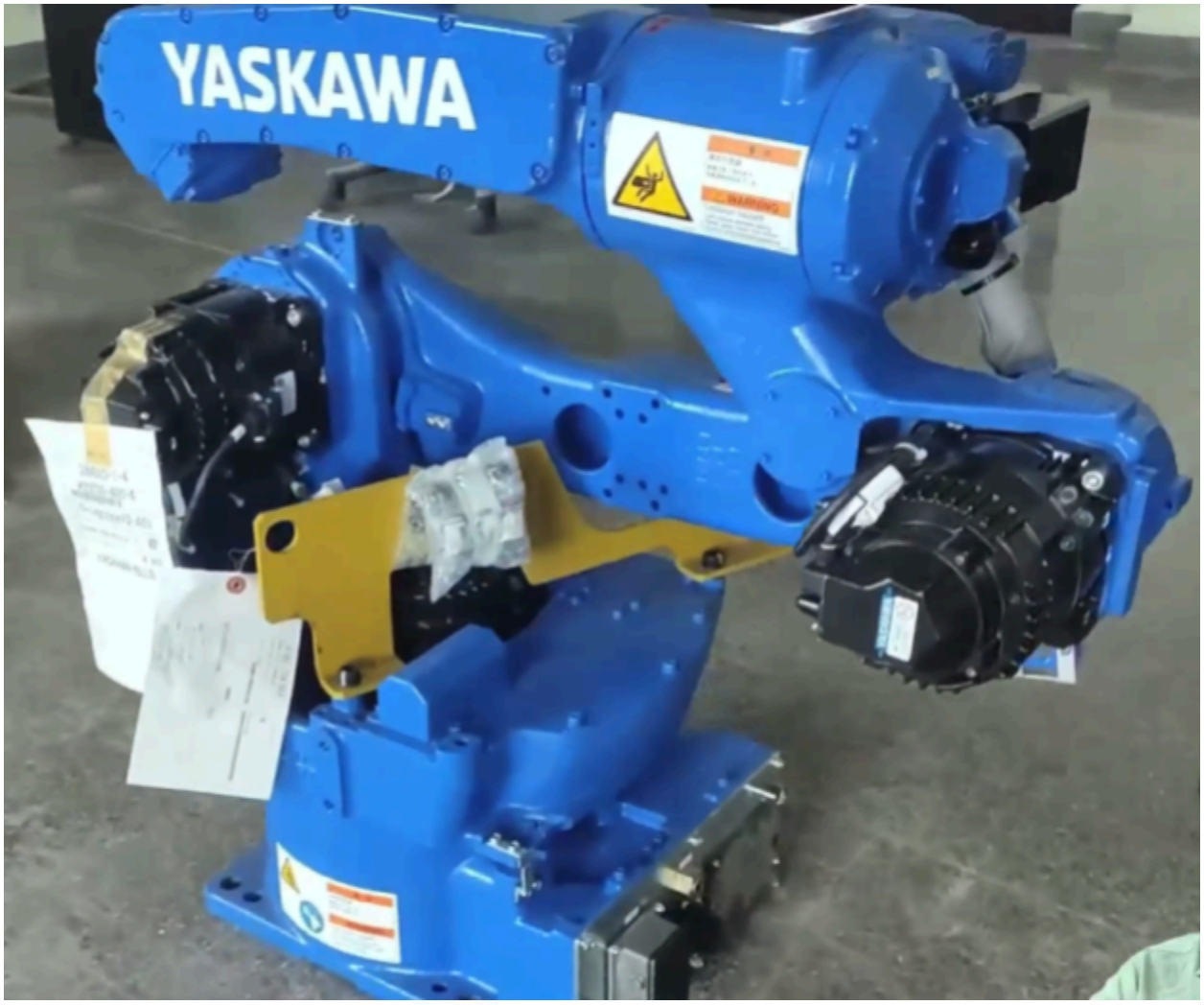
Check for the proper phase sequence. So, sometimes robots are three-phase robots, so your electrical phase should be correct. All the red, green and blue phases, or you call it a three-phase electrical connection, should be in proper sequence. It cannot be like this. That can be easily understood by checking the direction of rotation of the cooling fans. If it is there, cooling fans also use the same electricity. So, the direction may reverse if all this phase is reversed. Okay, so without this your robot will not start. Also, okay, use dedicated cables that are provided by the manufacturer to connect the robot controller, teach, pendant, and any input and output. The manufacturer does not normally provide input and output. It can be a third-party device, but you should confirm to the guidelines given by the manufacturer of the robot, as well as to the manufacturer of the I/O systems which are there. Let's say if it is device net profits; whatever it is, so you should take care of that.

Do configurations for input and output. That is required for all the input and output by default. It is not configured to be used in your robot programming, so that needs to be configured. Any attachment that comes apart from the robot controller-dedicated I O- so needs to be configured. So, that has to be done before you start, and this is something very, very important. So, sometimes, during transport, the robot might have got stuck somewhere, or it might have hit anywhere, so it may require something which is known as mastering of the robot. So, this is a very specific procedure which is to be followed in order to do mastering. We will cover this in a separate module also. So, it has to be done with and without the load. If at all, a robot is pre-mastered. Normally, it comes with smaller robots. It comes pre-mastered from the manufacturing site directly to your university, so it can be put to use without actually mastering. It can be done by electronic procedure, or some inbuilt software techniques allow you to do self-mastering of the robot before it starts for the first time. So that can be done.

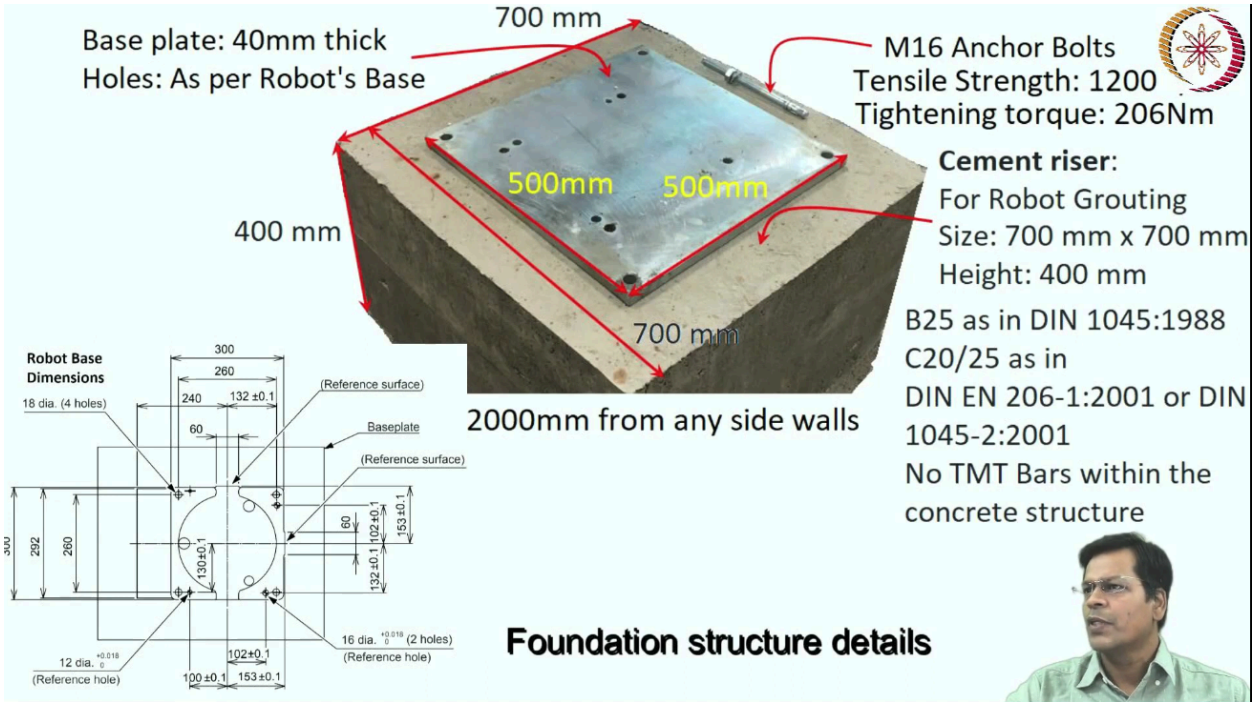
So, you need to calibrate your tool centre point. So, it is the centre point of the end effector tool that needs to be calibrated before it is put to use because, by default, Your robot knows its flags, but it doesn't know the tip of the tool. So, while moving, that is to talk to the robot about where it is and how it is oriented, the base of the robot fixed tool: if it is there on the workspace, within the workspace, that needs to be precisely located and known to the controller. So, you need some sort of calibration to do that. Your workpiece needs to be calibrated. All the calibration procedures will again be covered in a separate module, so that will also be done in a separate lecture. I will be doing it.

So, enter the node data. So, the robot, by default, again, knows the moment of inertia and masses of its length. But whatever tools and mountings that you add on top of this robot, it doesn't have any information about that. So, that needs to be calibrated and entered into the robot controller so

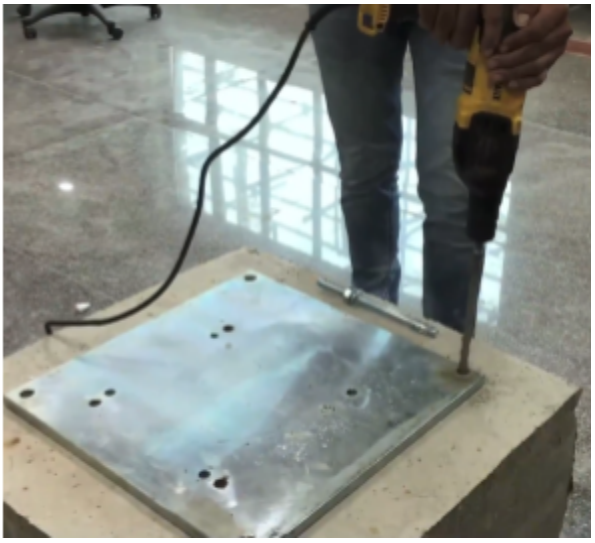
that it can perform its best, and you need to jog all the robot axes before you actually make it run, program the robot, and when you program, you should run at the slowest speed first, test do some trial runs across the workspace, then you put that to use. So, before we move ahead, I will just show you some video demonstrations along with that, I will show you. I will explain the rest of the things.



So, let me start this video first. So, this is the robot, and you see, it has this yellow part of the robot, which is the frame that I was talking about. So, this is the frame which is used to transport this robot to this long distance. Okay, and you see, there is a hole at the rear part of this robot. This is the place where all the welding harnesses can pass, your pneumatic lines can pass, whereas all the dedicated cables are pre-fitted by the manufacturer. You see, it is already there in place. So, and this is the mounting flange. This is the location where you can put your supplementary loads. Okay, you can put it here. This is the place where all the cables will go, all the cables will go.

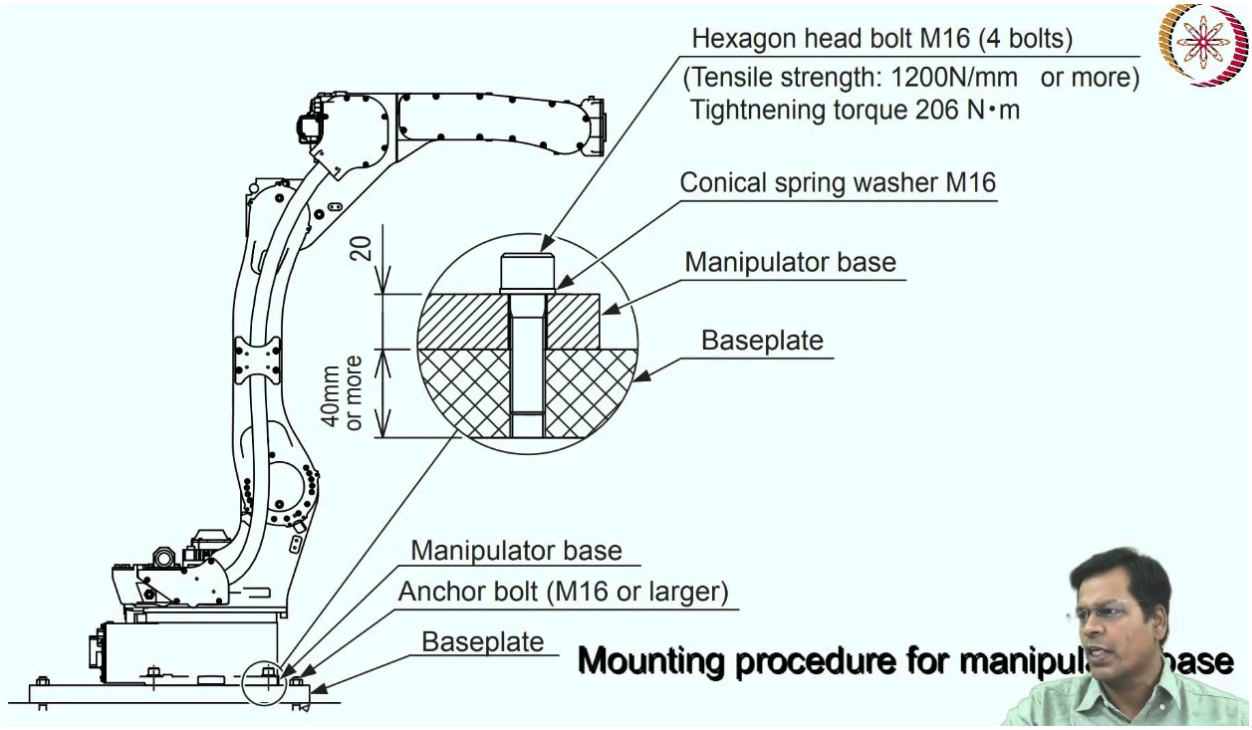


Now, the floor is being prepared where you can build the riser or the concrete block on which this robot will go. So, this is a complete structure for that. So, this is there. So, this is it. So, you see, you have a concrete structure which is made up of size 700 by 700 mm; because my robot has something footprint size was 500 by 500 mm, I know my footprint size, so accordingly, I have decided to put it by 700 by 700 mm. okay, so that sufficient clearance is there, and I can push all my bolts through without breaking any of the edges, and the concrete structure was then standard 1045:1988, or there are other similar standards. That specifies the concrete structure. There are no bars within this concrete structure because you have to put the mounting bolts or the anchoring bolts. I will show you how they are fitted. This is one of them of M16 type, which you can see of tensile strength, as specified by the robot in the previous lecture, tightening torque is also given: 206-newton meter. It is different for different robots. Just for example, I am telling you baseplate is something 40 mm thick, baseplate which are holes as per the robot's base, as per the robot footprint. You see, it is there. Robot's base dimension. This I have extracted from the robot technical data sheet, and those exact holes are made over here. So, this is the metal plate that will fit on top of this cement riser through grouting bolts and anchoring bolts, and the robot further will go on top of this, so this is how this structure is made.

Now, I will drill that concrete structure using this drilling machine, a hammer drill machine. So, this plate was put on top of this and I can just put some marker and do the drilling. So, this is how the holes are made. You see, the depth of the hole is as deep as this anchor bolt is. So, this concrete should be completely stiff before you actually do this. It should not be wet still inside. Now you can push in your. Once all the holes are done, you can push in your anchor bolts. You can push it through, okay, and then measure the clearance and tighten it before you actually put the other bolts. This is the first one that is done, and the diagonally opposite one is now placed. The first one is placed because this allows the plate to be firm enough. While you are drilling other holes, this doesn't go off, so the diagonally opposite one was chosen next. So, that should be the sequence. So, I have put the plate on top of this and it also is put firmly now. These are anchor bolts. They don't come out if you pull it again or you tighten it further. Okay, so there are many such kinds which are available, of different makes. Okay, so this is the first one that is done, and this is the second one. All the bolts are now put. I am quickly forwarding it. Now, all the bolts are fully tightened to the recommended torque, as I have discussed earlier, 206 Newton meters. Once it is fully tightened, now, you can cut the extra part which remains. All the bolts are cut and properly ground before it is put to use.

Now, the robot can be placed on top of this metal plate. My robot was 150 kg, so it was easier to do this way. Otherwise you can have dedicated cranes which can take you there. Okay, so see, still, that transport frame is there, and the same thing is done on the other side. Okay, so this is the first one that is done, and this is the second one that is done, and this is the second one that is done, and this is the third one that is done, and this one is still there. That yellow colour one transport bracket is still there shipping bracket, and that is later on removed. That helps you to pick up and place this robot itself. They are aligning the holes properly.

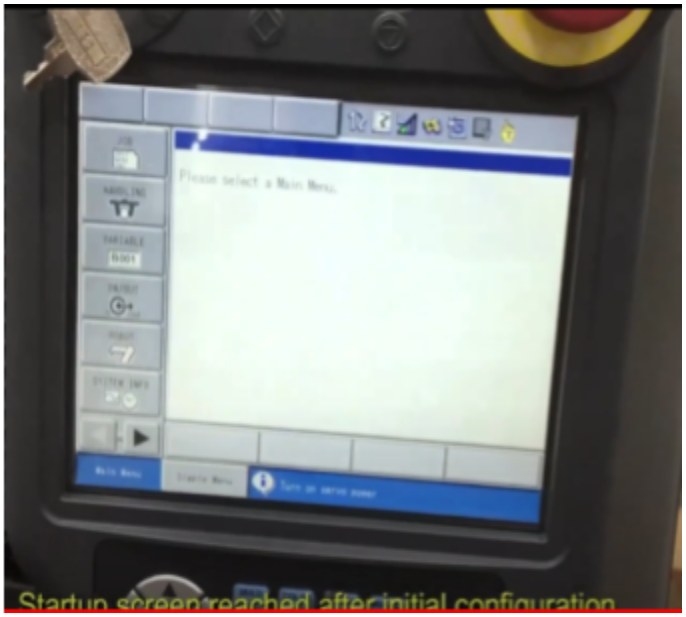


So, this is where your baseplate is. Then, the anchor bolts are there and the manipulator base. That goes here.

So, this is how it is put. Complete details are here. The baseplate mounting and conical spring washer are there, of M16 size. Now, it is fully tightened one by one, all the hex bolts. Okay, now that all the bolts are tightened visually, it is inspected thoroughly, and so this is what is a spigot, that is, the locating bolts. Reference spigots are posted properly so that it does.S not. It allows you proper alignment and precise robot operation. So, while the robot is in use, it does not move. Okay, so now your robot is fully mounted, only mounted. So, you see, the robot flange dimension was there before we actually put the gripper there. So, it was matched properly using some adapter spacers. It is also there so that it properly matches the flange dimension of the robot to the flange dimension of the gripper. All the screws are placed.

You should take care of the depth, which is mentioned in the datasheet, and also properly tighten to the torque which is specified there. Now, this is a 5 by 2 way solenoid valve that will actually actuate this gripper. So, before it actually works, this is the compressor with FRL, 6 bar pressure, and 50 liters tank capacity. So, manual valve switching is done in order to see its operation, whether that finger is properly working or not, without an actual controller being put to you. So, you see, this solenoid valve is mounted at the designated location on the first link. So, that it moves along with the robot. Okay, so this is the spot which is pre marked and given in the manual that it has to be mounted here only. Okay, now this mounting bracket is removed. That is the shipping bracket, that yellow colour frame, you see. So, the controller cable outlet is connected here. That goes to the robot. Finally, the arching cable is already connected here. This

is to teach the pendant, and the controller cable is connected. One end goes to the end of to teach pendant, the other end goes to the controller. In this three-phase socket, all the three phases are properly understood. Before it is actually put into the circuit breaker, which is there, it may require a dedicated transformer to convert to the appropriate voltage level properly. In this case, it is 220-volt phase to phase, and sometimes it is 440-volt phase to phase. So, you have to look for the proper specification of the robot datasheet. So, this is the circuit breaker which is connected to the circuit breaker.



This is a five-point plug with three phases: one neutral and one ground. The robot can now be started. It boots up. Initial configuration is done. After that, all the IOS are connected. Now, the robot is up one by one. We will test it for operation one. Each of the axes is now made to move manually by jogging: axes one, two, three, four, five, six.

That's all. So, now your robot is ready, got it? So yes, that is, the robot is ready to move manually by jogging.

That's all for this lecture. In the next lecture, we will put this robot to use Initially by mastering this robot so that it can be programmed and made to run. Now, we have just jogged, we can program it. Before that, we have to do a mastering of the robot. Why that is required and how it is done, we will discuss in the next class. That's all. Thanks a lot.