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# Module No # 02 Lecture No # 09 Fall hazed in Concerting

Welcome you all, so today's class we are going to discuss about concrete in construction and demolition operation. So, these 2 operations have a major hazard if you look at is primary falls. So, in the last class itself in regard to falls we have discussed about scaffolds. Scaffolds is where workers tend to move and complete their work. So, in general it is a referred as workers platform. So, the other one is primarily the formwork which we will see in today's class.

So as a result of some failures or the way in which formwork is not putting place in constructions, there are lot of fall hazards and a lot of failures in constructions also.

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So, now a quick introduction to what is concrete? Everyone knows what is cement? And when it is mixed with water, generally we get something as a cement paste. And this actually used as a glue or a binder in construction. And the cement plus fine aggregate so plus water when it is mixed you call what is called mortar. And the mortar you know very well it is used for brick masonry construction and again it serves as a binder.

Then, cement plus fine aggregate plus what you call coarse aggregate and little of admixture where ever it is required. So, with all these combinations you call what is called concrete. So, this concrete is what we are going to see in today's class.

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Now, if you see general concreting operation involves 3 steps primarily but we also say 4 steps. I will tell you what is the 3 and 4 steps. So, number 1 process is primarily called shuttering of formwork. And number 2 is primarily reinforcement and third one is placing or pouring concrete. So, these are the 3 steps when the concrete has attained the strength, we primarily do deshuttering that is termed as a fourth operation, fourth step.

So, these are the 3 processes, we have and we are going to talk more about shuttering only other than these 2. This concrete related hazard we will discuss along with the health issues because more health problems are related to concrete. And reinforcement we will discuss along with hazards with caught in between or struck by or so on. So, this we will discuss along with the crane operations. So, these 2 I am not touching upon today.

So, what we are going to discuss is formwork or shuttering. So, what is a formwork? Formwork is a temporary mould that acts as a support for the fresh concrete. Otherwise, concrete is a flowable material unless you give some support and proper shape than we would not get concrete into desired shape. So, formwork in very simpler form it act like a support so that it get the desired shape of the building.

So, now they are so many ways of concreting formwork available these days it can be partially fabricated or it can be completely fabricated. You also get manufactured commercial products available these days. Or you can also go directly and do conventional ways of you know customizing and doing the formwork also for small-small construction jobs, so all ways are available.





Now let us talk about the temporary structures. There are lot of terminologies that come together. So, along with the formwork the term comes together; which are all inter-exchangeably used are formwork, centering, shuttering, staging and scaffolding. So, what is a formwork? As I told this is a nothing but a mould to actually pour in the concrete. So, this is a primary a bridge pier construction.

So primarily you create all the formwork structures. So, when you pour the concrete, it gets the shape of the inside of the formwork. Centering is the nothing but the horizontal temporary arrangement. In a way slab formworks are generally called as centering.

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The next one is shuttering all your vertical temporary arrangements are primarily called shuttering. So, columns or your wall formworks are generally called shuttering. So, this is a picture to show you wall formwork, which is also called shuttering. Then, next one is staging are all your props and supports either for centering or for shuttering which implies either for vertical support or your horizontal supports. All your props and supports are nothing but are called staging.

And scaffolding is actually as I said, it is a worker's platform, wherein workers try to reach the construction site or the place of work where they have to do. And it is primarily like a helping the workers and material movement. So, these are the different terminology and all these are called temporary structures. The minute the actual building construct is completed then all these structures will be removed from the site.

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# Requirements of Fals Press Esc to exit full screen

Strength and Stability - should withstand all types of load

- Safety (should support the concrete & workers) and Integrity (adequately braced laterally and diagonally)
- Rigidity (achieved by ties & braces) and Deflection deflections under the DL, LL, forces caused by ramming and vibration of concrete, other incidental loads, etc. imposed upon it during and after casting of concrete are well within permissible limits
- Erection and Release shall be designed and constructed that they can be removed in parts in the desired sequence without damaging or disturbing other sections or causing collapse of the formwork systems
- Should facilitate ease of Inspection

Should permit maximum reuses thereby reducing the cost of concrete work (should be designed with a viable reuse plan that requires minimum cutting, wastage and assembly)

So now what are the requirements of false work? So again, if I have to recap and tell, there are lot of types of formwork for example jump formworks, slip formwork. Then, we also have climbing formwork, tunnel formwork, table formwork. So, like this they are so many varieties available and I am not going to talk about all those specialized varieties. We are only going to discuss about general strengths and safety issues on formworks.

So, what are the requirements of formwork? Because it is only a temporary structure and once the permanent construction comes in place all these temporary structures will be removed. So, why to worry much on this formwork? No that is not the way it should be looked at because the strength of the formwork also affects the quality of construction or even the strength of the actual construction also.

So the first requirement the formwork should have enough strength and stability should withstand all type of possible loads that comes on to the formwork. It should be very safe; it should support the concrete weight it should support the worker's weight. And also, it should be you know primarily having a lot of integrity with the structure. So that even with whatever lateral forces or vertical forces or any way the force comes in it actually stands firm and stable.

It should be rigid which is achieved by lot of braces and ties and it should be having a sufficient amount of deflection, which is within the permissible limits. There can be lot of deflections which can happen because of the dead load coming on to the formwork. When the load of the fresh concrete live load because of the movement of workers and equipments. And also forces caused by pumping in of concrete or vibration of concrete as a result of compaction.

So, all these should be taken into account so the formwork should be very much very rigid and stabile. Erection and release obviously formwork is not like a use and through purpose. It should be serving for multiple rounds of construction. So based on the lifecycle of material of construction, the life cycle of the formwork also depends on. There are lots of materials with which the formwork is generally coming these days.

Starting from timber or even aluminum or steel formworks and so on. So based on the initial cost and maintenance cost these formwork life cycles are decided. So accordingly, the formwork should be so designed and constructed. That it can be removed in parts without collapsing the structure or without collapsing the formwork system as such so that it can be reused. And this should also facilitate ease of inspection.

Where ever the inspections are planned it should have may be a small window or something so that you can actually inspect the actual concrete if you want to do so. Should also permit maximum reuses so thereby the cost of concrete is reduced. And should be designed in such a way that it requires minimum cutting, wastage and assembling. So accordingly, the formwork structures should be designed and even.

And the actual construction also should be designed in such a way that there is no complex shape or a very particular shape wherein you are actually doing lot of waste of cutting and using of the reuse of the formwork. So, all these are the basic requirements for formwork.

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Now I have been keeping on saying there is lot of load acting on the formwork. So, what are the different forms of load which comes onto the formwork? Let us discuss one after the other dead load. So, if you talk about the dead load the self-weight of the formwork. Which is not like changing, it just acts on to the structure. This actual, self-weight of the formwork, the weight of fresh, concrete and any other temporary works, which is supported by the formwork, which can even be scaffolds or anything which actually is integral part of the whole temporary structure. The imposed load it can be storage of materials, lateral pressure on the fresh concrete or unsymmetrical placement of concrete. Generally, what happens when you pour in the concrete through pumps it is actually poured in one particular place only and the concrete starts spreading ahead.

So, there can be unsymmetrical imbalance of concrete load and as a result you may have different load acting on to the whole structure. Then, environmental load it can be wind, it can be seismic, it can be water pressure, earth pressure and so on. As far as possible the water table should be kept tight when you are using the formwork, because that water is really dangerous when it comes on to the formwork and to the structure.

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So let us talk about formwork in foundations. So, precautions should be taken to prevent burying of forms due to the collapse of the soil. So, what happens is generally the formwork need not be taken too much of precaution when it comes to foundation only the strength aspects are generally seen. Otherwise, the other formworks the neatness of the structure also depends on the quality of the formwork, but as far as when you talk about foundation.

It is not a too much of a worry for any contractor, but the other issue is the water table can cause serious problems and accidents or incidents and so on. And the forms may also be damaged if there is water table and as a result there can be collapse of the whole structure also. That you should keep in mind. So, proper planning and dewatering is most required when you are working below ground levels.

And also, this is also can result in accidents or incidents that you have to keep in mind. Now if you see the types of foundations there are so many types. But we are going to only talk about 2 here. One is stepped footing and other one is sloped footing and these are common terminology in any civil engineering. So stepped footing just like your steps you have different layer wherein the load acting on the above is spread across onto the foundation and to the soil below.

In sloped footing there is a tapering portion from where the load acting on the column is spread onto the foundation and to the soil below. That is primarily called sloped footing. In sloped footings the top forms are not a serious concern but it is based on the angle of repose that the top forms may be there. In stepped footing it is very simpler actually you have to know vary the dimensions.

Nowadays formwork comes with different you know series of dimension wherein you can alter the size accordingly. And the formworks can be placed to make a quick easy step ahead. That is primarily called stepped footing.

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Wall/Column formwork Columns- forms should be capable of being stripped easily. In tall forms it is desirable to provide windows at appropriate levels on at least one face to facilitate inspection, concrete placement and vibration. Any method (standard or patented) such as adjustable clamps, bolts, purpose made yokes, etc., to hold the panels in place may be used Walls- The two faces of shutters of the wall should be kept in place by appropriate ties with spacer tubes or bolts, braces and studs The container of shuttering oil shall be kept closed and put away from fire sources. Spillage of the oil shall be avoided. The crane operator shall be authorized and have adequate experience Slings used for lifting panel shall have adequate capacity, free from defects It shall be ensured that panels are locked with each other and rods and other means are not used in place of appropriate locks ile panels are lifted, there shall not be any loose material which food fall down. Lifting panels over people shall not be allowed. Panels shall not be released from crane unless they are secured. De-shuttering shall be done from the top

Now let us talk about formwork for super structure. So, the first one is wall or the column form which is also called shuttering. So, this is primarily a picture of a wall formwork. In the same way we have for column formwork and as such we call it as a mould also. When it wants to have a desired shape, it is primarily called as a mould or shuttering. So, columns forms should be capable of easily being stripped away in no seconds.

In tall forms it is desirable to provide windows at appropriate levels for proper inspection and also for to checking on to placement of concrete, to do vibration and so on. So, there should be an adequate window for doing all these small-small activities of the concreting work. So any method which is applicable can be used for connecting the panels in place and these are all called panels.

So, these panels can be connected in place not by broken reinforcement rods with is available in the site and so on. There should be a proper procedure for connecting the panels. Which can be adjustable clamps or it can be bolts or any other standard practice which is supposed to be done. Can be used because they also should take care of the load acting on to the temporary structure

Walls the 2 faces of shutters so what happens is this formwork first is they place the shutter than the place the reinforcement in between the shutters than they pour the concrete. So, the 2 faces of the shutters of the wall should be kept in place by appropriate ties. And these widths of the 2 faces of shutter should be maintained uniformly all across the wall formworks. And the spacing can be maintained by means of tubes or it can be braces or studs.

Whatever applicable practically it should be done and there should be a proper oil also on in order to you know remove the shutter after the concrete is placed. So, this oil container should be closed after applied on to the formwork and put away from fire sources. So, this will also eliminate fire hazard and spillage of oil if there is anything should be cleaned and maintained, also it should be avoided.

And the crane operator for lifting of the panels they should be properly experienced. Should be aware of how to lift the panels, which should be in the design briefs. So, unless the formwork is properly designed on to the lifting points and to so on, should be identified there itself and with that places only the formwork should be lifted in sites. The slings used for lifting panel should also have adequate capacity and it should be free from defects.

And it should be ensured when the panels are lifted no loose bolts or nuts or anything is falling off so on. So, it should be properly taken care. And when the panels are lifted it should go as a single piece and not like a loose hanging substance should not be seen when the panels are lifted. And when the panels are lifted again the workman should not be allowed to walk below those places because it is a fall hazard position.

And then lifting, when the panels are lifted unless the crane operator is assured that the panels have been safely secured. He should not release the panel till than the panel should be held with the cranes. And when de-shuttering happens it should be done only from the top, especially when you are having a, tall forms. So, these are the some of the safety precautions in column wall formworks.

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Next is the beam slab formwork, so this generally comes as a beam slab and accordingly some provision is maintained in the slab so that it acts together. So, no temporary structure or props should be erected on the soft soil unless the soil is really you know compacted and it is ensured that bearing is adequate below the props. And soft shuttering of slabs at upper stories should also be protected from blowing off through the wind.

Especially when, you are going on multi-storey connections on the top shutter when there is no load acting onto the shutter. In the sense when there is no reinforcement placed or when there is no concrete poured in then there can be a wind force which can blow off all those shutters. So, it has to be tightly fixed and secured in place. Panel dimensions of prefabricated side shutters should be fixed.

So that during pumping of concrete or pouring in of concrete the panels are not bulging and leading or giving way to the pressure which comes onto the structure. So that should be maintained otherwise there will be collapsed on the formwork and the concrete. Reinforcement steel rods or any other material should be in place with the help of lock pins and other means of locking should not be attempted.

The Scaffolding frames should be erected such that the ladders can be used for reaching on to the formwork or even otherwise the scaffolds and formwork can be aligned together. So, that the workers are having a free movement between the formwork and the scaffolds. If there is any

opening in the slab or roof opening so primarily for want of anything for passing of ducts or anything.

So that should be properly supported with planks and accordingly the slab should be casted. And should be kept closed barricaded and provided with safety nets below. By mistake if the movement happens, still the workers should not be falling off. There should be safety net below openings in left in the slabs. Edge of the formwork should have proper guard rails to prevent fall of workers.

While de-staging the formwork system, the frames and bracing should be lowered only using the rope and pulley arrangement. Although there is other means of manual handling of these destaging, but still it is recommended to have a rope and pulley arrangement. Workmen should not be allowed to stand below the formworks when the de-staging happens de-shuttering process is happening.

And also, the area should be completely barricaded not to allow the unauthorized people into the premises. De-shuttering materials should be stand neatly for future storage. So, side precautions common side precautions formal checks are recommended when the proposed founding level for the false work is in preparation. So, at different stages the falsework has to be checked for its strength.

When, the falsework has attained a height of 10 meters than there should be a formal check. At intermediate stages when the strength or stability of the formworks has been adversely affected with the environment conditions or loading conditions or may be unauthorized interference of anything. So as a result, it has to be checked and before applying the load in the sense before pouring the concrete again the strength of the formwork has to be thoroughly checked.

Also, vibrations when happening through needle vibrators can often you know try to you know alter the position of the props from their support base. When the needle vibrators are poked in the through the concrete for compaction then obviously there can be dislocation of the props. And hence so when the concreting is going on there should be a person standing for checking the safety of props.

And also, when some props are dislocated, the load acting on that particular prop will be transferred on to the adjacent props and yielding may very quickly happen and as a result the other props may fail. And as a result, there can be an accident or collapse of the concrete structure. And also, there should be a means of communications between the person operating the needle vibrator and the person standing below the level of the floor or slab in order to know due communications or signals that props has been dislocated. And until it is repaired and sufficiently corrected the concreting may stop will be stopped and then renewed.

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Electrical safety should be against electrocution should be taken care of when you are using electric shutter vibrators. Fire safety should also be taken care of and accordingly fire safety equipment should be in site especially when you are using timber formworks. And so, site welding so reinforcement when you want to have a larger diameter rods are used and when you want to connect 2 rod using welding.

Then accordingly it should not be done over any timber shutters the reinforcement should be taken the welding should be taken care of ahead of your placing in above the shutters.

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# Site Precautions while erecting formwork Erection of safety signs and barricades to keep unauthorized personnel clear of areas in which erection, concrete placing, or stripling is under way All provisions of the design and drawings should be complied with Any excavations nearby which can influence the safety of the falsework should be accounted for in the planning The bearing soll should be sound and suitably prepared. The sole plates should fully bear on the ground without possible settlement Safety measures should be taken to prevent impact of traffic scour due to water, etc. Adequate bracings, struts and ties should be installed with the progress of erection to ensure strength and stability of falsework at intermediate and final stages Places of stacking of materials should be marked as per the provision in falsework design and it should be ascertained that the stacking is done only at proper places Inclusion of lifting points in the design and detailing of all forms which will be crane handled The deterioration of materials due to storage, reuse and misuse should be checked and corrective steps taken for safety Incorporation of scaffolds working platforms and guard rails into formwork design and all

Some more site precaution while erecting formwork there should be proper safety signs barricades to prevent unauthorized people entering into the site. Also, while you are placing your formwork or while you are pouring in concrete or maybe you are stripping of the formwork during all precaution there should be erection and safety signs and barricades. All provisions of designs and drawing should be complied with.

formwork drawing

And as I said already it should not be miss understood since it is the temporary structure so the design and the safety precautions and the constructions of details whatever is given in the drawing should be really adhered too. And including the safety precautions because these temporary structures are very critical to give the final good quality construction later on to the permanent structure.

Any excavation nearby which can influence a safety of the false work should be accounted in the planning. If you wanted to erect the formwork there are few excavations which are close by then the soil has been already disturbed. So accordingly, that has to be considered while you are putting up your false works in your design and constructions. The bearing soil should be sound and suitably prepared. And also, that the there should be sole plates or base plates should be provided in order to prevent settlement with the ground levels.

Safely measures should be taken to prevent impact of waters traffic scour due to water and so on. And adequate bracings, struts and ties should be installed with the progress of execution. In order to maintain, the strength and stability of formwork at intermediate and final stages. There should be adequate places marked on your drawing itself where your material can be stored your equipment can be stored.

And only in those earmarked places your material and equipment should be stored when the concreting operation is going on. And no other places it should be done and you should be following the design criteria for that. Inclusion of lifting points also in the design for lifting the panels or the formwork panels should be clearly indicated. And the detail of the formwork also indicated when they are crane handled.

The deterioration of materials due to storage, reuse or may be misuse should be checked and corrective measures should be taken for safety precautions before you are using the formwork. Then incorporations of scaffolds working platforms and guard rails into the formwork design at all times should also be enabled so that you have a seamless movement of worker and equipment into the structure. So that also should be taken care of in the formwork drawing.

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During Concreting
Adequate access in the proper positions are provided for the smooth flow of men, materials and machines
> All precautions are taken to prevent accidental impact, scouring or flooding of foundations
> The forms shall be clean and free from wood shavings, grit, etc. Forms and joints are such that they prevent leakage of mortar and slurry.
<ul> <li>Only approved coating or form release agent are applied, and the reinforcement are clean from the same</li> </ul>
The sequence, rate of concreting, and method of placement and position of construction joints are as per the design brief
Reinforcement and falsework have been checked and permission to commence the placement of concrete has been accorded
The thickness of the concrete are maintained all along the member as per drawing
> The props and bracings should be watched during the placement of concrete and its vibration
Any members or wedges which may tend to become loose or shift should be attended immediately
<ul> <li>An agreed system of communication between the man below and the man in charge of concrete operations should be established so that corrective actions as required may be taken and concreting can be stopped instantly if at all it becomes necessary to do so</li> </ul>
Patforms for the movement of workers and mechanized concrete buggies are separate and are not placing load upon the reinforcing steel Go to Settinge to actuate Windows.

So, during concreting, so we have talked only about erection of formworks. So, during concreting adequate of access in the proper positions provided smooth movement of worker, material and equipments so all should be enabled. All precautions should be taken care of to prevent accident in terms of flooding in the foundation that also should be taken care of. The forms should be very clean and free from any wood shavings or may be dirt, grit and so on.

May be the earlier concrete which is available in the formwork everything should be cleaned up when formwork is in place, because it may affect the strength of the concrete. The forms and joints are in such a way that they should be preventing leakage any leakage of motor and slurry, especially during vibrations and pouring in of concrete. Only approved coating of form or release agent should be applied.

And this should not be touching up the reinforcement and the reinforcement should be very clean from the same. The sequence of putting in the forms and the sequence of removal of the forms, the rate of concreting, method of pouring in the concrete, the position of concrete joints everything should be as per the design processes and if should not vary from that sequence. The reinforcement and the false work should be checked.

And the permission to commence the placement of concrete should be then nodded by the site supervisor then only the concrete should be starting to pour into the structure. The thickness of the concrete should be maintained at all times as per the drawing. And as I said the imbalance level of concrete and one place of pouring in concrete all should be avoided as much as possible. The props and bracing should be maintained for proper strength and especially during the placement of concrete and vibration.

The concreting may also have to be stopped when catastrophic issues are happening in the site. Platforms for the movement of workers and for the mechanized concrete buggies should be separate and they are not placed and the load is not placing onto the reinforcement and it does not go to the reinforcement steel.

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In spite of this there can be so many reasons for formwork failures. Improper stripping and shore removal. What happens is initially when house or building construction happens first they put wall column formworks after the foundation and than they do the slab or the beam formwork putting all the props and supports. After this the concrete has attained sufficient strength so these props may be removed and the shoring generally happens.

And then the forms are actually replaced or put in into the floor above. And this shoring and reshoring keeps on happening unless the concrete has attained sufficient strength and so on. Now what happens is? Before the concrete is in a particular level has reached its sufficient strength if improper stripping happens here and there. Then, actually you are collapsing the structure without proper strength attained onto the concrete which is in the floor below.

And to start loading up the formwork and start pouring in the concrete in the floor above then obviously you may have formwork failure and accident can happen. Inadequate lateral bracing and especially when you are pushing up the formwork to floors above. You should take care of adequate lateral bracings, because the loads coming onto the lateral end may start increasing apart from the load acting to the formwork itself.

So that you should have adequate diagonal horizontal bracings of shores that also should be maintained and checked for during inspections and suggested for additional lateral bracings and ties should be maintained for the stability of the formwork. Vibration due to placing equipment so may be sometimes equipment such as vibrators which is moving around in the site for compassion of concrete. That can create vibration to the concrete and also to the formwork itself.

So, the forms sometime collapse because when you accidentally disturb the props or the support place then the forms can accidentally collapse. And so, forms can also be dislocated with movement of workers with the movement of vehicle moving around in the site and also the equipment on the formwork and the actual effect of vibrating concrete. So that should be kept in mind and you should be looking for the stability of the formwork at every time.

Unstable soil that also should be taken care of, this we have discussed enough. Inadequate control of concrete placement as I said there is a rate with which the concrete gets pumped or poured into the structure and the temperature starts differing. So, now when the rate of placement of or the pouring in of concrete is varying or the concrete is poured at different speed. Then what happens is the rate is generally varied and the temperature also generally varies.

This can create an imbalance on to the load and on to the structure so that also has to kept in mind and the lateral pressure overloading onto the forms. So, what happens is if this load anticipated in the design is not actually into the construction site, the formwork can fail. That should be kept in mind and accordingly it should be tested for the pressure and also for the temperature of the concrete which comes out of the pumps.

Lack of attention to the details, always the small ties, the nodes, the nails with which you use to bind or close the shutters all. Not much detailed attention is generally given but that is really essential because they also take care of some load that comes onto the formwork. Even when the basic formwork design is soundly conceived, small differences in assembly and the strength details all can happen and as a result a formwork can also fail.

So, this may be very simple like insufficient nailing or failing to tighten the locking devices and so on, so that should be taken care of.

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Removal of formworks and scaffolds and based on the type of formworks whether it is wall formwork or slab formwork and so on. It can be differences in the repetitions cycle and as such the formworks can be removed. And again, the material with which the formwork is made and here also there is a life cycle of repetition for re-usage. So that also be kept in mind and accordingly the shoring and re-shoring process will continue and this formwork will be used for the floor above and so on.

So that also should be taken care of and that should be borne in mind when you are planning for the formwork life cycle and the schedule of your constructions. So, what happens is the formwork and the scaffold when you are removing there should be some safety precautions you should keep in mind. The formwork should not be removed unless the concrete has attained sufficient strength. It need not be the complete strength sufficient strength wherein the shores and re-shores can help to you know balance the load.

So that should be kept in mind and the load acting on to the structure also you have to keep in mind whether that particular concrete has reached the strength and then only the formwork should be thought of removed. The formwork should be dismantled as per the sequence and instruction on the engineer or as given in the formwork drawing. The sequence of removal of formwork should be maintained at any point of time.

And workmen who actually know the procedure of removing the formwork should be allowed in the area and they should only be removing it as per the sequence. The person concerned and the workers who are actually stripping off the formwork should have the knowledge of the sequence of releasing the formworks and accordingly should know the props location left in position. The forms are eased off from the concrete faces to prevent the damage to either to the concrete or to the form. Accordingly, the forms should be stripped off.

And the forms and shores must not be removed until it is determined by the employer that the concrete has gained sufficient strength and superimposed loads that comes on to it. So, all the false work materials are properly stacked, maintained. And may be some time the quality checks are done and then actually it is reused into the next levels. Any members should not be allowed to be dropped from a height and should be carefully you know brought down because it may affect the strength of the formwork.

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So. these are the references from where the complete material has been taken. So, with this, this particular lecture is over. Thank you.