

Foundations Footings and Formwork a practical approach.

Good morning Ladies and Gents and esteemed colleagues of the NIOB firstly I would like to thank President Bldr Kunle Awobodu FNIOB for inviting me to participate in this online Workshop which I must say is quite a different approach so let's hope the next two days are very successful as each of the Speakers impart some of their knowledge and experience to you.

My presentation will be delivered from a practical point of view and understanding which in my opinion is often lost in the technical discourse of the day but which in my view is very important to get right.

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Foundations

Foundations are generally referred to as being competent, that is they are suitable to carry the imposed loads of the Structure and all the imposed live loads that will occur over the life of the building. So determining the suitability of the Foundations is the role of the Geotechnical Engineer who will undertake a Geotechnical survey of the proposed site by way of hand dug sample pits if applicable thru to Boreholes to a predetermined depth or to a point where refusal of the drill is recorded this is usually bedrock or some other competent strata.

Results from the Borehole will identify the different strata types along with a depth band i.e. from 1.200m to 3.000m medium grained sand to fine grained loam.. These readings are then recorded continuously. If there are any indications of moisture these are recorded thru to indications of water which is very important. You should make yourself aware of the soil classification tables which are relevant to your area these are often found with various engineering design codes.

Compilation of these results is then give the Structural Engineer the basis for him to calculate the Footing sizes and types so as the bearing pressure is such that the structure will not subside or settle unevenly. Through careful assessment and experience the Engineer will make allowance for any anticipated settlement over the design life of the building which is generally 25years although in some instances this may be considerably longer.

Over your career you may be lucky and have the luxury of building in nice gravelly or loamy clay soils but from time to time you may encounter a site that has varied soil types from sand to loam and gravel to rock or sand to wet muddy clay which has no bearing capacity at all. In this case there will be special a special need to Dewater the Site to allow the installation of Bored Contiguous Piles for ground support through Bored Piles to support the building. Dewatering can be from a simply Flexi drive Pump placed in a sump to a comprehensive Dewatering System with Suction Spears , Header Pipes and a suitably sized Dewatering Pump. These larger dewatering systems will also have licencing requirements as lowering the water table in built up areas can affect the existing buildings causing serious problems of subsidence and movement of the lightweight structure footings. Disposal of

water from dewatering operations will also need serious consideration, most serious dewater operations are carried out by specialist Contractors.

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Setting Out

Setting out on larger Projects is mostly done by a Project Surveyor engaged on the Project to carry out all setting out and the recording of As-constructed information. The Surveyor will establish a Datum where all the Reduced Levels are taken from and recorded against. From the various Co-ordinate information he is provided with the Surveyor will establish various Grid Lines or building lines to enable the marking out of Pad Footings and Strip Footing

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Piling

The installation of Bored Contiguous Piles or Curtain Walling for ground support through Bored Piles to support the building are mostly used where poor ground conditions are encountered or there are very large live loads being encountered. This method of construction is also used for constructing basement Levels and is referred to as Top Down Construction which will be a topic for another discussion.

Piles are typically of two types Driven or Bored Piles. Driven Piles are driven by a percussion hammer Piling Rig to a design depth to achieve the required bearing capacity or refusal that is the Pile cannot be driven any further.

Bored Piles are bored to various diameters and various design depths then filled with high strength Grout / Concrete Mix into which a Reinforcing Cage is lowered as required by design. To complete the integrity of the Pile or group of Piles a Pile Cap or Raft Slab is constructed to help evenly distribute the imposed loads then the remaining superstructure is constructed from that point.

Let's consider the Burj Khalifa Skyscraper in Dubai which features 192 Bored Piles of up to 1.50m diameter and bored to over 50 m deep. Some of the Piles in this structure typically rely on friction to support the structure that is the friction of resistance developed over the length of the Pile helps support the Structure which is quite unique.

But for the most of us we will be constructing buildings with Pad Footing or Strip Footings but just as important for the stability of the building. Footings are not just holes in the ground where we pour some of that grey stuff, they need to be accurately set out and accurately constructed to the dimensions required.

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Planning

Planning the excavation sequence and process is a very important part of this sequence of works. If the Project has a lot of in ground services such as Plumbing , Stormwater and Electrical Mains these will need to go in first and be co-ordinated as there may be common services Trenches or Ducts. If

possible careful planning should consider the location of these Services so they do not clash with the Footing depths. Consideration should also be given to the location and depth of **Temporary Services**, these should be clearly recorded and “marked up” on a Site Plan.

Careful consideration needs to be given to how the Footings will be excavated for example simple Strip or Pad Footings in compacted Sand for a simple House maybe dug with Labour and hand tools while more complex and extensive Strip and Pad Footings for a Commercial Building will be dug by using a Back Hoe or small Excavator then using Labour to do final trimming up..

Consideration needs to be given to what do you do with all the excavated material, some may need to be used for backfilling or you may need to stockpile it onsite to be reused for other Activities. You may have a very restricted and congested Site and the Spoil will need to be taken offsite and stored for later use. The Site may have Footings at different Levels so the Site may be excavated to allow Footings to be placed at the various Levels then backfilled up to take the next level of Footings so a lot of careful planning is required in this instance.

Depending on where your building is being built you may have to deal with contaminated Soils. There are special Environmental requirements that need to be observed when disposing of contaminated Soils. The contamination may be from Hydrocarbons from previous operations or there may be Acid Sulphate Soils which will have a serious effect on the Concrete causing long term degradation. Accurate Records and Quality Control needs to be put in place when dealing with any contaminated Soil removal, this may include dumping and treating it where it is going to be stored.

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Footing Types

There are many different **Footing Types** and they all have different functions within the structure but I will just cover the two main Footing types.

Strip Footings are those which will generally support Brickwork or Insitu Concrete Walls or carry the edge of a Edge Thickening of a Raft Slab. Strip Footings will also be used for the base of Retaining Walls with the addition of dropped edge toes and thickenings. Strip Footings may also have thickenings to pick up isolated Columns which may be installed to support future Brickwork.

Pad Footings are simple isolated Footings of various sizes and depths which will generally support Steel Columns or Concrete Columns. With Steel Columns there will be a set of Holding Down Bolts accurately set out by the surveyor prior to pouring and after the pour to do an ‘as con” survey which is very important as any discrepancies can be picked and modifications made to steelwork before it comes to site. With the increasing use of Precast Concrete Columns there is also a need for accurate setting out. There may be Holding Down Bolts to pick up a Steel base in the Precast Column or Chemical Anchors maybe used and approved by the Structural Engineer.

If your building has a Lift or number of Lifts then the **Lift Pits** will need to be considered early in the process. Lift Overrun Pits also have some special needs. As well as the Pit Base being a heavy Raft Footing it will in most cases require some type of Waterproof Membrane to be applied to the Base and Walls.

Sometimes you may be lucky and be able to excavate the Footings directly into the soil onsite. But there may be occasions where you will need to form each Footing or use sacrificial or lost Formwork, there are a number of proprietary Brands available for lost formwork which are cheap and easy to

install. One of the benefits of temporary or lost formwork is to keep the Footing to the correct size but also keep the reinforcing from being compromised with inadequate Cover.

As mentioned earlier consideration of Services passing through the Footings needs to be carefully understood and executed. Generally any Service that passes through a Footing must be sleeved or wrapped with an isolation foam strip and securely fixed so as not to be displaced during the pour. The Engineer may also document that a suitable thickening is dug under the Service to maintain the integrity of the Footing.

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Quality

How do you measure Quality unfortunately on busy Sites this can be overlooked but it is a very important part of the project. Unfortunately many of the Building collapses we see and hear of can be directly related to some failure of omission or failure to construct the element as it was intended to be constructed. The Quality requirements are clearly articulated in the Project Specification and Notes on the Structural Drawings. These Notes and Specification Clauses will clearly identify what the Engineer requires. The points are covered will relate to Earthworks , Concrete , Reinforcing , Formwork and other specific requirements that the Engineer has identified and requires to be done. These Notes are also provided to help provide stability as the structure is being built without imposing unforeseen live loads on the Structure or Temporary Works.

From these Notes the Project Engineer will compile a set of **Inspection Test Plans referred to as ITP's**. The ITPs are developed from the Specification and the Engineering Notes, they will identify **Hold Points and Witness Points** which will require some one to sign off that that Task has been satisfactorily carried out.

For the Site Agents , Site Managers he or she will usually inspect the Works along with the Artisan Leading Hand using a purpose written Check List .

The Check Lists will cover Earth Works , Reinforcement placement , Cast in Items , Dimension Control, Concrete Placement and other items identified as needing to be checked and confirmed they are correctly located.

These Check Lists are very important documents and must be accurately completed and Filed for future reference.

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Formwork

On today's fast paced construction sites boundaries are being pushed with Design , Specific Client requirements and many other needs. With these large scale Projects many of the large proprietary brands of Formwork have been specifically designed around the use of their particular components.

But from time to time you will be required to install simple suspended Slab Formwork whether its for a House or a suspended slab for a large commercial Project. The system will most likely be Props , Bearers and Joists standing on Sole Plates or something similar. This is where the experience of a good Site Manager comes into play, the Site Manager will continually inspect the Works as they are being progressed each day raising concerns of various items he finds.

- Many collapses occur because basic understanding of Formwork has not been followed such as;
- Props are placed too far apart
- Props not tied together
- Sole Plates fail
- Bearers incorrectly located in U Heads and not secured.
- Bearers are in poor condition
- If Frames are being used the Jacks and or U Heads are extended too far causing them to fail.
- Or simply the Rate of Pour has over loaded the Falsework placing uneven loads of the Falsework causing it to fail.

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Conclusion

The construction and placement of the various types of Piling ,Footings , Pits and the like play a very important part in the success and future stability of the Structure. The Roles of good Site managers , Quality managers and Artisans all play a part in the success of this part of a project.

The importance of good Quality Control and Quality Assurance Practices cannot be under stated here , take a short cut eventually it will come to light as unforeseen loads are being imposed on part of a structure causing catastrophic failures.

These failures have a serious impact on the Industry through loss of credibility and huge financial costs but most of all loss of life ...can you afford to have that on your consciences .

Thank you.