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Underpinning Techniques and their Applications in Strengthening of Different Types of Existing Foundations

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Introduction

Underpinning is a method for repairing and strengthening of building foundations. Underpinning methods, procedures, and their applications in strengthening of different types of foundations are discussed in this course. There are situations where a failure in foundation or footing happens unexpectedly after the completion of the whole structure (both sub and superstructure). Under such emergency situations, a remedial method has to be suggested to regain structural stability. Underpinning method helps to strengthen the foundation of an existing building or any other infrastructure. It involves the installation of permanent or temporary support to an existing foundation so that additional depth and bearing capacity is achieved.

What Is Underpinning?

Underpinning is the process of strengthening or supporting and stabilizing the existing structure of the foundation. This underpinning process is done by extending reinforcement in a breadth of the existing foundation or in-depth of an existing foundation.

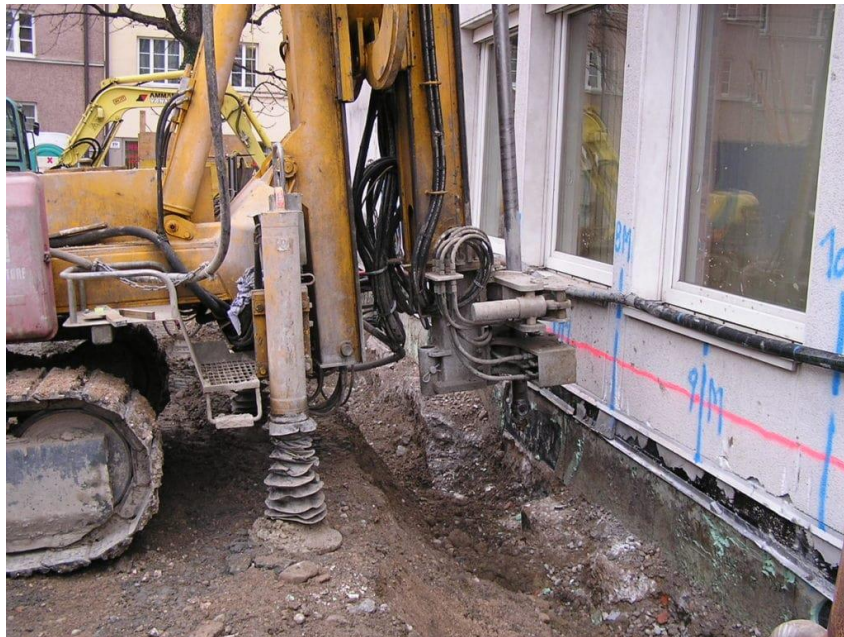


Figure 1. Underpinning Methods, Procedure, use in Foundation Strengthening and repair

Selection of Underpinning Methods

Underpinning methods are chosen based on the age of the building and the kinds of work it has. Depending on how old a building is, it is classified as:

- i) Ancient Structures are older than 150 years.
- ii) Recent Structures: Ages between 50 and 150 years.
- iii) Modern Structures: Ages under 50 years.

Types of works for selection of underpinning methods

Conversion Works

The structure has to be converted to another function, which requires stronger foundation compared to existing.

Protection Works

The following problems of a building has to undergo protection works:

- the existing foundation is not strong or stable
- nearby excavation would affect the soil that supports existing footing
- stabilization of the foundation soil to resist against natural calamities
- requirement of basement below an already existing structure

Remedial Works

- Mistakes in initial foundation design caused subsidence of the structure
- Work on present structure than building a new one

Structural Conditions Which Requires Underpinning

There are many reasons that make an engineer to suggest underpinning [method for stabilization](#) of the substructure such as:

- The degradation of timber piles used as a foundation for normal buildings would cause settlement. This degradation of structures is due to [water table](#) fluctuations.
- Rise and lowering of the water table can cause a decrease of [bearing capacity of soil](#) making the structure to settle.
- Structures that are built over soil with a bearing capacity not suitable for the structure would cause settlement.

Purpose of Underpinning

Underpinning is done for the following purposes:

- a) For the purpose of leading an old shallow foundation to the deeper depth when the adjoining building is constructed with a deep foundation.
- b) Underpinning is done for *building a basement* in the existing building.
- c) Underpinning is done to deepen the existing foundation (resting on poor strata) and make it rest on deeper soil strata of higher bearing capacity.
- d) To strengthen a settled foundation that may be caused by cracks in the wall.

Need for Underpinning

The decision of underpinning requirement can be made based on observations. When an already existing structure starts to show certain change through settlement or any kind of distress, it is necessary to establish vertical level readings as well as at the offset level, on a timely basis. The time period depends upon how severe the settlement is.

Now, before the excavation for a new project, professionals have to closely examine and determine the soil capability to resist the structure that is coming over it. Based on that report, the need for underpinning is decided. Sometimes such test would avoid underpinning to be done after the whole structure is constructed. It can be summarized the necessity of underpinning in the following points.

Necessity of Underpinning Foundation

Underpinning foundation is a necessity:

- a) when an original or existing foundation is not stable at that time underpinning is required
- b) when the purpose of the structure is changed

- c) when the supporting or strengthening **soil** property of the foundation is changed
- d) when mischaracterized during the design of the foundation
- e) when the existing foundation soil structure is disturbing during the **construction** of nearby structure

Methods of Underpinning

Underpinning can be carried but by the following methods:

- 1) Pit method
- 2) Pile methods
- 3) Underpinning to walls
- 4) Jack pile underpinning
- 5) Needle and pile underpinning
- 6) 'Pynford' Stool method of underpinning
- 7) Root pile or angle Piling Underpinning columns

Pit method

In this method, the entire length of the foundation to be underpinned is divided into sections of 1.2 to 1.5 m lengths. One section is taken up at a time.

First of all, a hole is made in the wall for all divided sections above the plinth level, and needle is inserted in the hole. The needle may be made of a material of stout, timber or steel section.

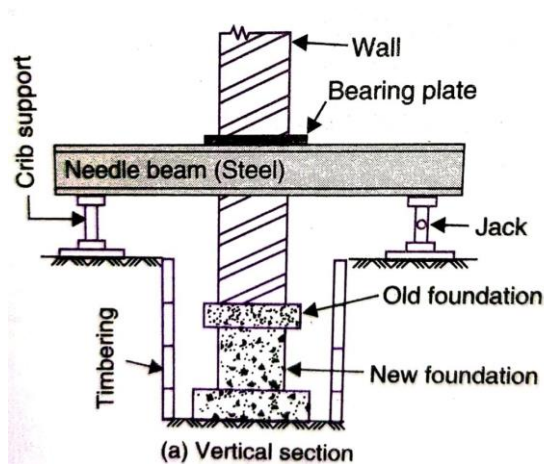


Figure 2. Pit Method of Underpinning

Bearing plates are placed above the needle to support the masonry above it. The supporting arrangement of the needle is made by crib supports (wooden blocks) on both sides of the wall and screw jacks.

After that, a foundation pit is excavated up to the required level of new foundation. Then the new foundation is laid in the pit. When the work of one section is over, work on next to next section is taken up, i.e., alternate sections are underpinned in the first round, and then the remaining sections are taken up. Fig2. above shows the section.

Some *important precautions* should be taken during the work, such as raking shores are provided in week wall, floors are also supported.

In this process cantilever needle beams may be used when a strong interior column is there, or if there is a required foundation increasing in only one side, as shown in Fig. 3.

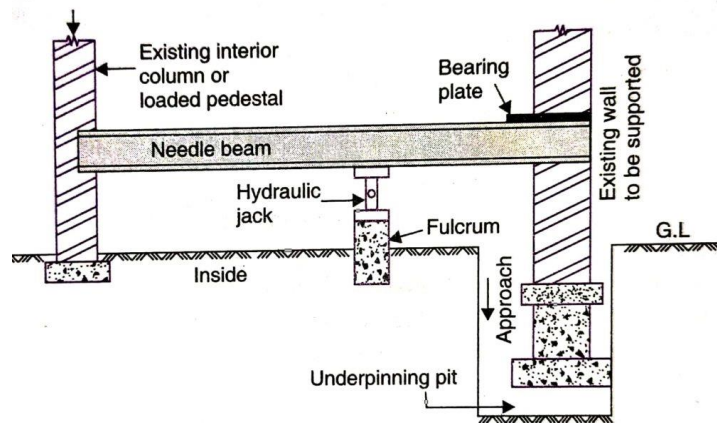


Figure 3. Pit Method of Underpinning with Cantilever needle

The following points are to be considered in the pit method:

- 1) Alternate sections are taken up in the first round. The remaining intermediate sections are then taken up. Only one section should be taken at a time.
- 2) It is better to start the work from the middle in the case of long wall extended in both directions.
- 3) If the new foundation is deeper, proper timbering of the foundation trench may be done.

- 4) When the foundation has gained full strength then only all the arrangements like needle beams etc. should be removed slowly.
- 5) The needle holes etc. should be closed in masonry using cement mortar.

Pile method

In the Pile method of underpinning, as the name suggests Piles are installed by proper driving technique along both sides of the wall to be strengthened. The piling technique normally used are borehole pile on under-reamed piles are used.

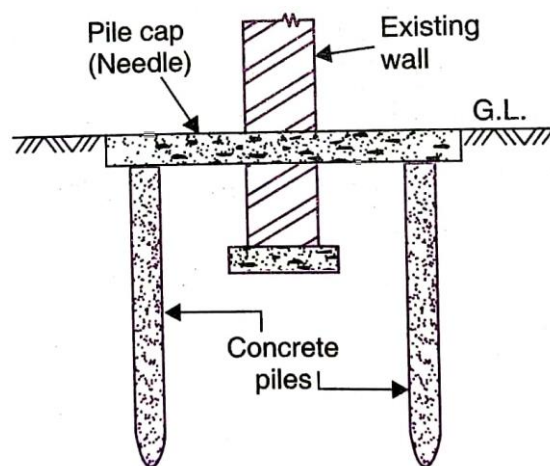


Figure 4. Pile Method of Underpinning

After that, concrete or steel needles are penetrated through the wall and are connected to the Pile. These needles function as beams and act as pile caps as well. Pile method is suitable for clayey soils, waterlogged areas, and also in weak bearing strata. Besides from above, followings are the Underpinning Types and Techniques used for different structures:

Underpinning to walls

For underpinning work in walls, the wall should be divided into legs for bays and is bay is treated individually that prevents fracture, damage, or settlement of the walls.

The below are the factors that affect the length of the legs and bays:

- a) the overall length of the wall
- b) the dead and live loads on walls
- c) the bearing capacity and types of soil under the existing Foundation
- d) the strength and stability of the walls and foundation of the wall which is going to be underpinned
- e) the estimated differential settlement and spinning ability of the existing wall footing

For **mass concrete strip foundations** supporting walls of traditional construction, the suitable bay is **1 to 1.5 m**, and for moderate loading walls supported by **reinforced concrete strip foundations**, the bay length is **1.5 To 3 m**.

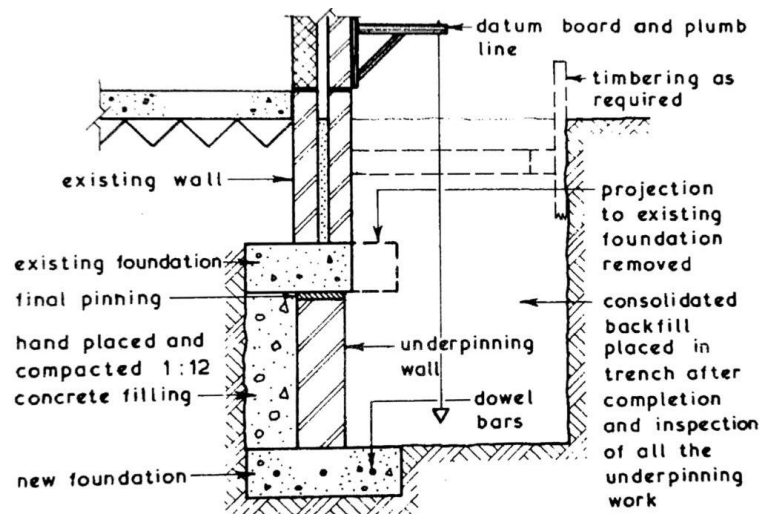


Figure 5. Typical Traditional Underpinning details- typical section of Underpinning Bay

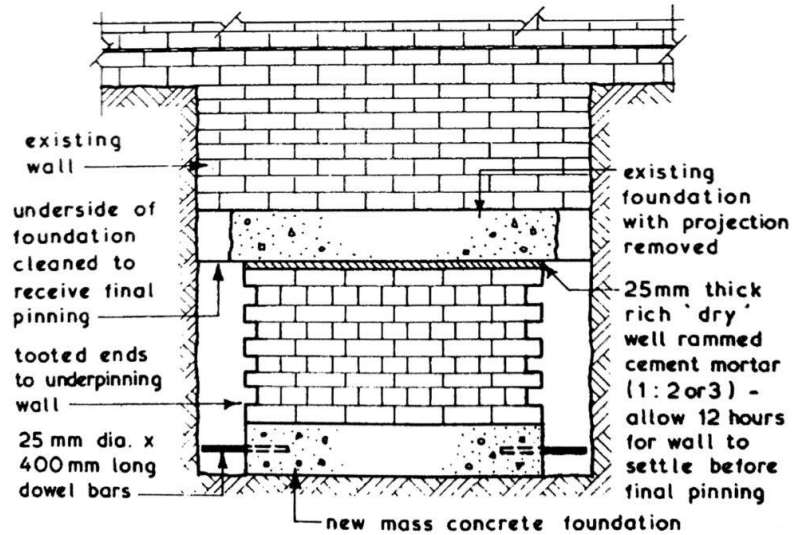


Figure 6. Underpinning bay – Typical Elevation

(Note: In all cases, the sum of the **unsupported length of wall** should not exceed 25% of the total length of the wall)

Jack pile underpinning

Jack pile underpinning is done where the traditional underpinning is uneconomical because of the depth of suitable bearing capacity of subsoil. The main advantage of Jack Pile and defining is it is **vibration-free and flexible** because the pile depth can be adjusted to suitable subsoil conditions encountered. In this system, the existing Foundation is span over the heads of the pipe caps which are cast in onto the **Jack pile heads** after the hydraulic jacks had been removed that Makes the Foundation in good condition.

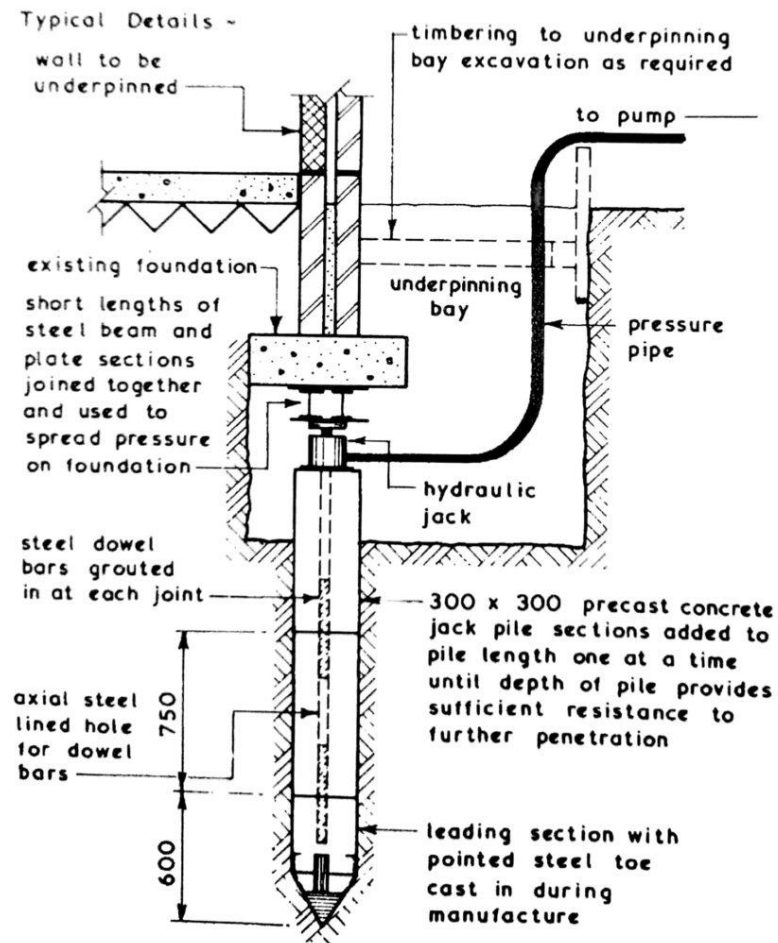


Figure 7. Typical section of jack Pile Underpinning

Needle and pile underpinning

Where the traditional or Jack pile underpinning techniques are unsuitable for the existing Foundation condition, then the needle and pile underpinning method can be used for the best result. As shown in the figure below the big work in this method above the existing Foundation should be **in a sound condition**. And the piles used are generally in small diameter bored piles.

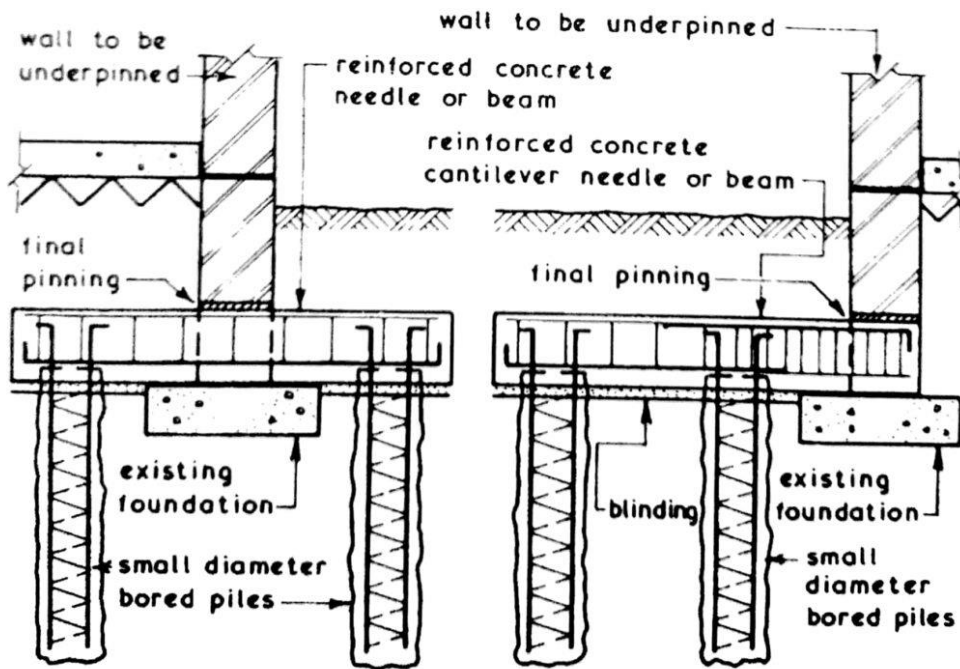


Figure 8. Needle and Pile Underpinning Sections

‘Pynford’ Stool method of underpinning

Pynford underpinning is used when the existing foundation’s soil is **poor bearing capacity**. This method of underpinning is suitable, and this method makes the needle run continuously to the walls.

The below are the detailed stages of this method of underpinning:

Stage I. Holes formed in the wall to receive steel or precast concrete stools.

Stage II. Stools inserted and pinned to the soffit of brickwork over the opening.

Stage II. Brickwork between pined tools removed to leave wall supported on pined stools.

Stage IV. Reinforcement fabricated and placed around pinned stools.

Stage V. Formwork erected and beam cast.

Stage VI. Formwork removed, beam allowed to cure before being pinned to the underside of the wall.

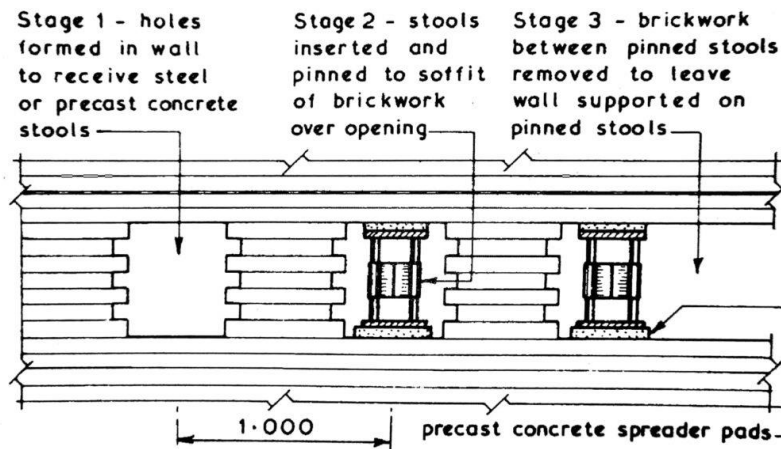


Figure 9. Pynford method of Underpinning stage 1 to 3

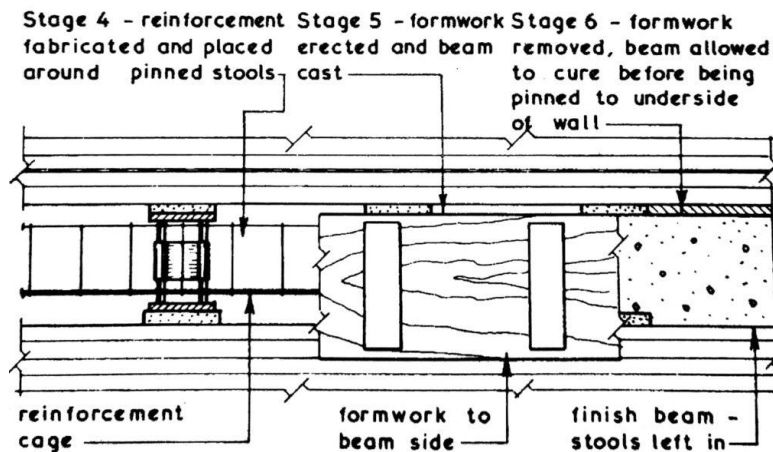


Figure 10. Pynford method of Underpinning stage 4 to 6

Root pile or angle Piling

In the root pile underpinning method, there is an application of **modern concrete drilling equipment** to achieve fabricate concrete that is economical through time-saving. Due to the above reason, this is a simple alternative to traditional underpinning techniques. There is no need for a large volume of excavation, show this message is not a disruptive bulk work

comparatively. Lined reinforced concrete *piles installed in pairs at opposite angles* make the wall stable in where the sound building starter is located not more than **1 to 2 m**. In this process the existing floor, wall information is pre-drilled with air flushed percussion auger. Fig below details.

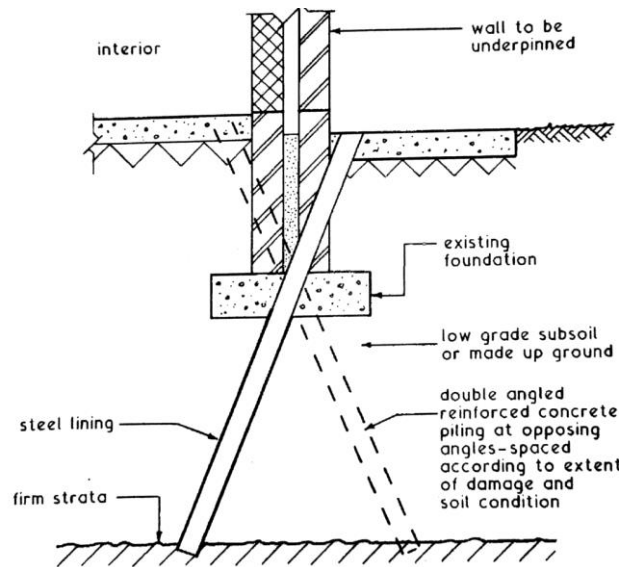


Figure 11. Root pile or angle piling method of Underpinning

Through this drill hole, *steel lining* is driving to the low grade/clay subsoil until it impacts with firm strata. In many conditions, it is very difficult to apply angle piling to both sides of a wall. As for the subsoil condition sometimes, it is down with the remedial treatment from one side only. For more stability piles are placed relatively with close space.

Underpinning columns

In the column underpinning first of all the *loadings are relieved* then it can be underpinned in the same manner as walls using traditional or Jack pile methods. **Dead shores** are used to transfer the beam load from the column and the column is transferred by means of a pair of beams.

Figures below show the details about Underpinning Columns.

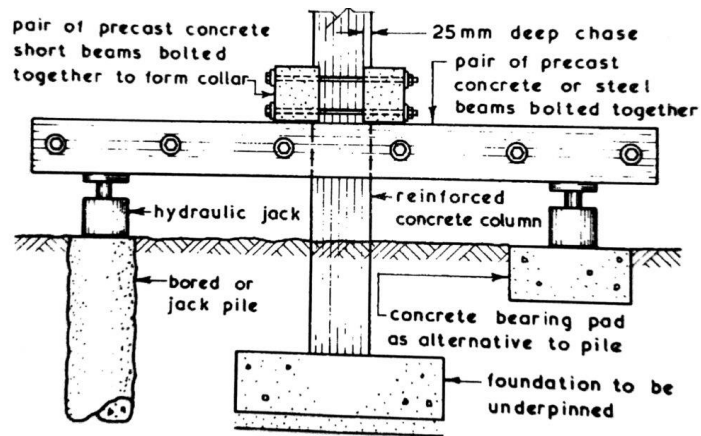


Figure 12. Underpinning Columns – Typical details

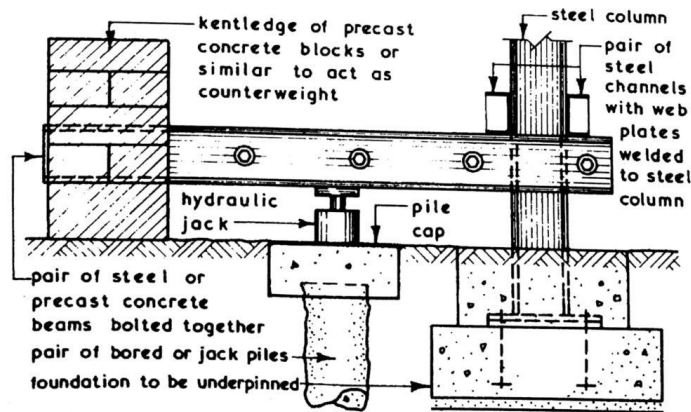


Figure 13. Underpinning Columns typical section with kentledge load

Advantages of Underpinning

Underpinning has the below advantages:

- Underpinning is good because it strengthens the foundation and protects it from all kinds of disasters.

- With underpinning, you can get more light into your building. You add new rooms or offices to your building and add more windows and doors so that natural light can get in.
- By underpinning your basement, you can get to your home's plumbing, insulation, and wiring to see if they need to be fixed.
- One great thing about underpinning is that it raises the value of your home. If you want to sell your home in the future, it will be worth more and give you a good return if it is well-built and has finished underpinning.
- Underpinning is a great way to add more space to a structure in a way that costs less and causes less trouble. Buying a new house could be expensive if you want more space, but underpinning can save you that money. Also, you won't have to pay for expensive repairs down the road.

Disadvantages of Underpinning

Underpinning has the below disadvantages:

- The nature of the underlying foundation method is expansive.
- When unstable and flooded ground, it is exceedingly challenging to underpin buildings.
- On the working site, a significant volume of excavated material is dumped during excavation.

Conclusion

Underpinning is a technique used to reinforce and restore the foundation of a building. By underpinning, existing buildings and infrastructures can have their weak foundations strengthened. One such method is adding permanent or temporary support to an existing base to increase its depth and load capacity.

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