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# A Review of Underpinning of Various Structures

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**Abstract:** ***Existing buildings or especially monuments and historical buildings sometimes experience ongoing settlement or face the prospect of excessive settlement in the future if a change of building use is required and foundation loadings increase, or due to environmental problems and natural activities. Underpinning method is used for strengthen the support system or foundation of structure. Due to lack of land, increasing population, increasing loading, settlements of buildings due to various reasons and raising number of vehicle demand it is not easy to provide parking place for parking. So it is necessary to provide parking place below the building. In this paper we have focus on various types of underpinning, advantages, Disadvantages, and case study related to applications of various structures.***

**Keywords:** settlement, foundation loadings, Underpinning method , underpinning

## 1. Introduction

The soils deform under the load of foundation structures. The total vertical displacement that occurs at foundation level is termed as settlement. The cause of foundation settlement is the reduction of volume air void ratio in the soil. Settlement in a structure refers to the distortion or disruption of parts of a building due to unequal compression of its foundations. Undue loads being applied to the building after its initial construction. settlement should not be confused with subsidence which results from the load-bearing ground upon which a building sits reducing in level, for instance in areas of mine workings where shafts collapse underground. Some settlement is quite normal after construction has been completed, but unequal or differential settlement may cause significant problems. So to over come from the state of failure of foundation due to settlement we use underpinning.

In construction or renovation, underpinning is the process of strengthening the foundation of an existing building or other structure. Underpinning may be accomplished by extending the foundation in depth or breadth so it either rests on a more supportive soil stratum or distributes its load across a greater area. Use of micropiles [1] and jet grouting are common methods in underpinning. Through semantic change the word underpinning has evolved to encompass all abstract concepts that serve as a foundation.

## 2. Necessity of Underpinning

Underpinning may be necessary for a variety of reasons:-

- The original foundation is not strong or in stable condition.
- The properties of the soil supporting the foundation may have changed or were mischaracterized during design.
- The construction of nearby structures necessitates the excavation of soil supporting existing foundations.
- To increase the depth foundation or load capacity of existing foundations to support the addition of another storey to the building.
- It is more economical, due to land price or otherwise, to work on the present structure's foundation than to build a new one.
- Earthquake, flood, drought or other natural activities have caused the structure to move, requiring stabilization of foundation soils and footings.

## 3. Methods of Underpinning

Underpinning can be carried but by the following methods:-

- Pit method
- Pile methods
- Underpinning to walls
- Jack pile underpinning
- Needle and pile underpinning
- 'Pynford' Stool method of underpinning
- Root pile or angle Piling Underpinning columns

### 3.1 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.

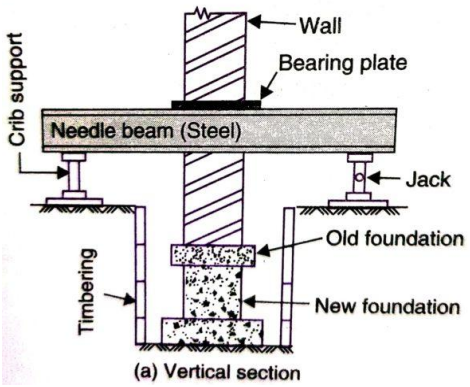


**Figure 1:** Pit method of underpinning

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.

### 3.2 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 techniques normally used are borehole pile on under-reamed piles are used.

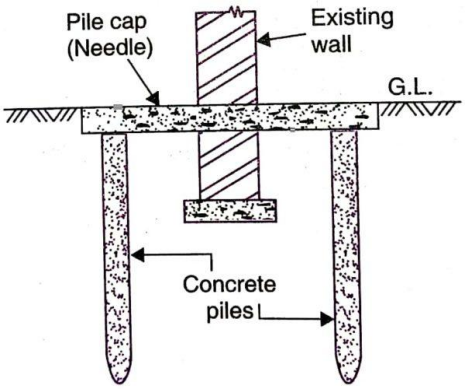


**Figure 2:** Pile Method of underpinning

After that, concrete or steel needles are penetrated through the wall and are connected to the Pile. These needles function is as beams and is act as pile caps also. Pile method is suitable for clayey soils, waterlogged areas, and also in weak bearing strata.

### 3.3 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. 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.

### 3.4 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.

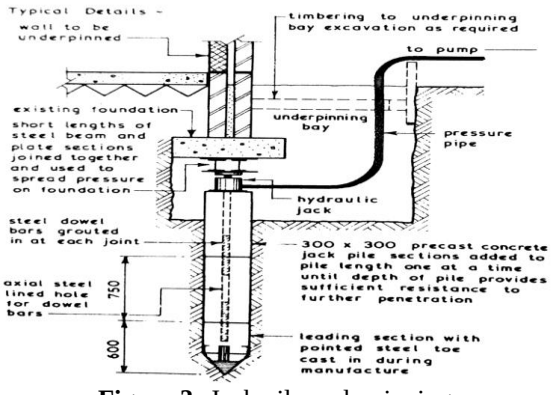


**Figure 3:** Jack pile underpinning

### 3.5 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 we in a sound condition. And the piles used are generally in small diameter bored piles

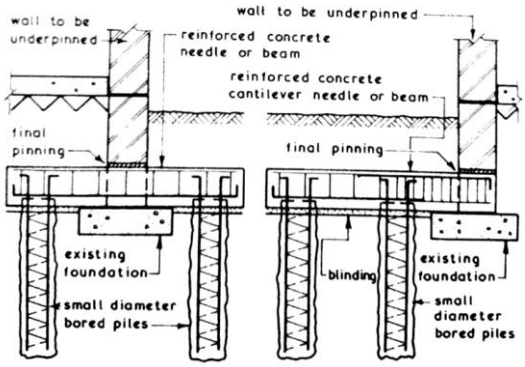


**Figure 4:** Needle and pile underpinning

### 3.6 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. Holes formed in the wall to receive steel or precast concrete stools. Stools inserted and pinned to the soffit of brickwork over the opening. Brickwork between pined tools removed to leave wall supported on pined stools. Reinforcement fabricated and placed around pinned stools. Formwork erected and beam cast. Formwork removed, beam allowed to cure before being pinned to the underside of the wall.

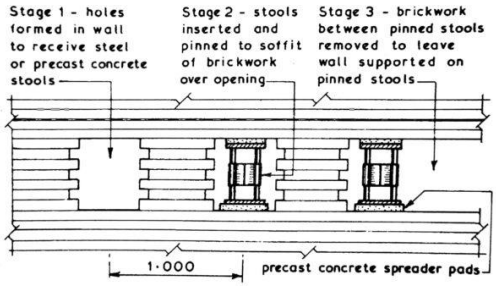


**Figure 5:** Pynford stool of underpinning

### 3.7 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.

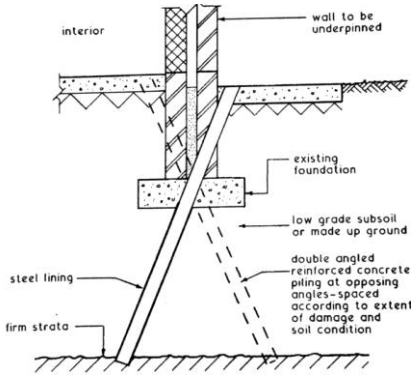


**Figure 6:** Root pile or angle piling

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.

## 4. Case Study

### 4.1 Case Study on Hussmann buildings Paris

Hussmann buildings architecture spread throughout the city of Paris. The building complex is constituted by two Haussmann buildings, built between 1830 and 1841. Nevertheless, those buildings are nowadays submitted to heavy operations of use change, conservation and rehabilitation, justified by several reasons, among others are building aging and the increasing demand for hotel rooms in Paris. In this building it was necessary to create an additional basement floor is described. This description is the result of a construction survey realized during a heavy rehabilitation operation which takes place between 2015 and 2017 in a Haussmann complex located at La Madeleine. This work aims at providing contributions for a better understanding of concrete pouring technique, complementary an evaluation of the risks associated with this technique is done.

To increase the depth of existing foundations, when adding one or two basement floors, one of the most commonly used technique for underpinning the existing foundations is concrete pouring, This technique consists in excavating the soil under the existing foundation and pouring concrete to construct a new wall and its foundation at the desired level. the excavation operation must be done regarding three main conditions. First, the length of the foundation underpinned is limited by the foundation strength to span over the excavated length but also by the pit shoring system resistance, for this reason, the wall beneath the existing foundation must be realized excavating and concrete pouring sections with a maximum fixed length.

### 4.2 Underpinning Engineering of Bridge Pile Foundation

Pile underpinning technology can not only effectively protect existing buildings but also solve the problems of urban transportation and underground space construction. In the process of strengthening the early Winchester Cathedral, the submersible workers used the underwater digging technology to reach the gravel layer after crossing peat and silt and then filled it with concrete to carry out the underpinning construction. After World War II, the pile underpinning technology was applied in many German projects, and a series of theoretical research studies were carried out, and the underpinning technology was listed as its industrial standard. Underpinning construction was adopted on line 9 of the Berlin subway so that the subway tunnel can be constructed normally. In the Swedish Imperial Palace, built in the middle of the eighteenth century, the side hall inclines due to the wood pile foundation and uneven thickness foundation soil, and the effect was remarkable after the pile foundation underpinning methos was selected.

An active underpinning technology was adopted in Kyoto Metro Station of Japan, and the underpinning structure could meet the design requirements by controlling the settlement of piles. 2e underpinning technology in China started relatively late, but with the massive construction of the national infrastructure, the number and scale of underpinning projects continue to grow. 2e underpinning technology was used for the first time on line 1 of the Guangzhou subway; in addition, the underpinning technology was adopted in the construction process of Guangzhou subway lines 2–6. On the basis of a large number of theoretical and experimental research studies, the active underpinning technology is used to cross the department store, and the implementation of a real-time monitoring technology in the process of construction has been used to ensure the reliability of the project . 2e Cheng-Mian-Le Passenger Dedicated Railway which cuts through the Expressway Elevated Bridge of Airport and underpins the two piers, respectively, in the form of “two piles to support a cap”. 2e single-span integral girder was used to underpin two piers in the bridge of the Shenzhen subway cut through Guangzhou-Shenzhen Railway, and the train continued operation during the underpinning construction.

In summary, the current pile underpinning technology mostly relies on construction experience, but the theoretical and experimental studies are relatively few. 2e specification for the underpinning technology of a country has not yet been formally promulgated. At present, the design of the underpinning structure is fully referred to the relevant design specifications of the concrete structure, but the study on the shear calculation model and the practical formula of the concrete structure is relatively few, only the semitheoretical and semiempirical formulas. Based on this, the truss-arch model is used to analyze the shear-bearing capacity of the underpinning structure, and the correctness and reliability of the proposed formula are verified by the comparison of the theoretical and experimental results.

## 5. Advantages of Underpinning

1) Improved Structural integrity:- Your structure’s foundation may have been improperly constructed or been damaged by repairs, extreme climate changes, or have simply wear and tear of age. One of the advantages of underpinning is that it will make your foundation strong and it will make sure that the foundation is protected from all sorts of calamities.
2) Enhanced ceiling height and lighting:- Underpinning will allow your structure to have better lighting fixtures. You add new rooms or new offices to your structure and also

add some more windows and doors that will allow the natural light to fall in.

3) Updating plumbing, electrical fixtures and insulation:- Underpinning your basement will allow you to access all the mechanics of your home like plumbing works, insulation and wiring, therefore you can check if they require repairing.
4) Increased value to your property :- One of the greatest advantages of underpinning is that it enhances the value of your property. If in future you plan to sell your property then a proper structure with finished underpinning will have a higher value and you can get a good return for your structure.
5) Bottom line:- Underpinning is an excellent, less expensive and less disruptive way to increase space in the structure. Buying a new property could be expensive if you want more space, therefore underpinning can save you from that cost. Moreover, it will save your from the future expense of extensive repairing.

## 6. Disadvantages of underpinning

1) There are large amounts of excavated material to be disposed of.
2) There are large amounts of concrete to be imported to construct the bases.
3) Excavations and bases are difficult to construct in unstable or water-logged ground.
4) Base depths in excess of 3.0 metres are generally uneconomic and create a number of health and safety issues.
5) Mass concrete underpinning generally requires good site access due to the amount of spoil to be removed and concrete imported. If access is difficult, the technique is more difficult and may prove costly.

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