

Reuse of foundation

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1 INTRODUCTION

Reuse of foundation is very popular topic for designers and developers especially in major cities. The designers deal with foundations of previous buildings quite frequently. Reuse of foundation is also interesting for investors and during the design process can be saved a lot of money to the investor. It is possible to anticipate the increase of material costs and therefore the discussion about reuse of foundations will be more popular in the future. The construction design of reused foundations presents additional design purposes which were not usually included in the past design processes. This paper describes the strategy which shall be adopted by designers considering reuse of foundation.

2 POSSIBILITIES OF FOUNDATION REUSE

2.1 *Shallow foundation*

Reuse of shallow foundations is usually problematic because the designer of the new construction is limited by the level of the original shallow foundations. This problem is usually with the old buildings, which were mostly founded too shallowly below the ground level. The original buildings in cities were usually relatively low and also the shallow foundations have relatively low bearing capacity. The nowadays constructions contain several underground floors and therefore the original shallow foundations are unusable and they have to be demolished. The foundation and underground floors of currently built high level constructions may be used in the future for different constructions. The current designers shall consider future reuse of foundations of buildings.

2.2 *Piled foundation*

The piled foundations are widely used from 1950's. Piles were mostly used in areas with soft geological conditions. The buildings were replaced 2x or 3x in one place since then. The relatively often replacing of buildings in one place is the reason for thinking about future foundation reuse. The span of every new building columns are usually larger and therefore the piles with higher bearing capacity were required for every new building. The every new generation of buildings contained also new foundations (piles).

The designers nowadays have to deal with the previous generation of foundations. The designers can also reuse existing foundations of buildings. The figure 1 shows the possibilities of existing piles reuse. (Chow (2003) and Butcher (2006)).

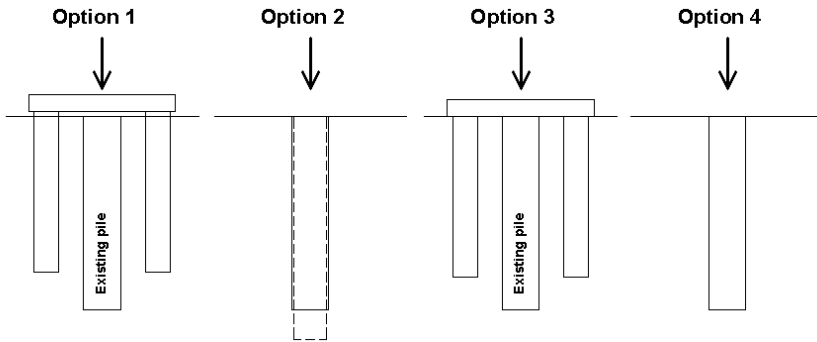


Figure 1. Possibilities of existing piles reuse.

Option 1 – Previous foundation do not taken into account

This is the easiest option for the designer. The problem may be with the new piles location. There may be the collision with the previous piles located in the ground. The new piles possible location may be also problematic for the upper construction disposition. The new piles location may be also affected by existing underground structures and other problems.

Option 2 – Existing foundations are replaced by new foundations

The existing reinforced piles are re-drilled and re-concreted by new piles. This option is technically difficult operation and also very expensive. The foundation costs of the replaced piles construction are usually much higher then expected. The cost of one re-drilled pile is 2-5 times higher then drilled pile in the non problematic area.

Option 3 – Existing foundations are partially reused

The existing foundations carry only part of the new load. The advantage is that the designer can make decision which part of the load will be taken by the original foundation. There are several options for determining the original bearing capacity of piles.

Option 4 – Existing foundations are fully used in the new structure

This option is possible to use in the cases where the load of the new building is approximately same as the load of original building. This option can save a lot of costs connected with the design and realization of new foundation. The major advantage of this option is saving time which is needed for realization of new foundation.

From the above options it is possible to state that in mostly cases the applicability of reuse of foundations is therefore:

- where the type of original foundation are piles
- where is no place for additional piles or where the underground is already filled (by tunnels, deep drainage)

3 ADVANTAGES, DISADVANTAGES AND RISKS OF REUSE FOUNDATIONS

The investors planning the utilization of the field usually do not tolerate any risk connected to the construction. The investors are usually willing to pay new foundation costs instead of build the new construction on the „uncertain” foundations. Therefore it is necessary to provide enough information of the reuse of existing foundation to designers, clients and also insurance companies. The real possibilities of reuse of existing foundations shall be clear to all parties. It is necessary to verify following information before making the decision of reuse of existing foundations:

- the location of existing foundations and their size
- current conditions of existing foundations
- the bearing capacity of existing foundations and settlement occurred during life of the construction
- the evidence that the existing foundations will be working the next life cycle of the new construction

The additional costs for reusing of existing foundation are relatively low to compare with the costs needed for new foundations design and construction. Those aspects are seen from table 1 below.

Table 1. Reuse of foundation additional costs and possible savings

<u>Savings</u>	<u>Additional costs</u>
site investigation costs	the investigation of the condition of the existing foundation
new foundation design	the design of connection between existing and new foundations
time for existing foundation demolition	upper construction adaptation for existing foundation
time for new foundation construction	interaction of existing and new foundations
excavated ground disposal	
time for unexpected cases (archeological sites)	
construction environment impact	

4 THE CONDITION AND BEARING CAPACITY OF EXISTING FOUNDATIONS

The designers usually do not know a lot of information about the existing foundations. They do not usually have any information about the original design and construction of existing foundations. The usual problem also is if is possible to trust the original information. The only evidence we have is that the foundations carry out the existing construction. This is the real situation and we can re-calculate the bearing capacity of the foundations. Reusing the existing foundations shall be based on:

- The design report of the existing foundations including the bearing capacity of the originally designed foundation.
- It is necessary to consider the original site investigation. If the new construction cause additional stress in the ground than it is necessary to ask for new site investigation.
- The original construction shall be documented before demolition. This will be the evidence that during the construction life time there were not any large settlements or bearing capacity problems. The existing constructions weight shall be well calculated and recorded.

Chapman (2002) and Chapman (2003) is using reuse load factor (R). It shows the value of the bearing capacity of the existing foundation utilization.

$$R = \frac{\text{new foundation load demand}}{\text{old foundation working capacity}}$$

The reuse load factor R shall not be mixed up with the factor of safety (FS). If the reuse load factor R=1, than the safety factor of the foundation is same as the safety factor of the original design. This may or may not be satisfactory for nowadays codes and calculation principles. If the reuse load factor R = 0.5, than the safety factor of the foundation is double than the original design assumed. The reuse load factor R can be obtained differently:

- R_0 – is based on the original design
- R_c – is based on recalculated design. There is also implemented the latest theoretical knowledge and calculation processes
- R_t – is based on original forces which the original structure loaded the original foundations
- R_p – is based on the load field tests results of the original foundations

In case of lack information about the original foundation structure it seems to be the best parameter R_t . This parameter is based on the real observation. The knowledge of original forces is crucial for this option. This knowledge shall be done before the demolition of the original structure. The original structure shall be well and credibly documented. The loading from the existing construction shall be documented and the forces to the existing foundation shall be well known for the future using. Unfortunately in many cases is the original structure demolished before the designer starts thinking about reusing the foundations. Discussions about reuse of the original design is then useless because it is not possible credibly determine the original loading of the foundations. Reuse load factor R_t and corresponded safety factor is illustratively seen on fig. 2.

Bearing capacity calculation of existing foundation shall also include:

- Existing foundation were designed using the theory at the time of original design. This theory may be quite different from nowadays knowledge.
- Recalculation of original foundation is based on new (more realistic) models and geotechnical parameters of soils.

5 FOUNDATION DESIGN WITH RESPECT OF FUTURE REUSING

The main problem with foundation reuse design is the lack of serious information about the original design and construction of existing foundations. Designers today shall design new foundation with respect of this. The designers and construction companies shall prepare enough information about the design and construction of foundation for future generations. For the future design shall be well known at least:

- Engineering geology reports including the results of laboratory tests of soils provided.
- The design of foundations including calculations, used codes and input data.
- Construction sequence and mechanization used
- Geotechnical and construction feedback reports including co-ordinates of the piles placed, length and piles diameter
- All loading test reports
- Quality reports of materials used in the construction
- Record of all problems during foundation construction including their solution.

There shall be produced independent description of realized construction including documentation. The following designers shall use those results without doubt. Very important is to provide independent documentation for future designers. They will trust the information provided. Documentation provided by construction company during construction will not be reliable for future designers.

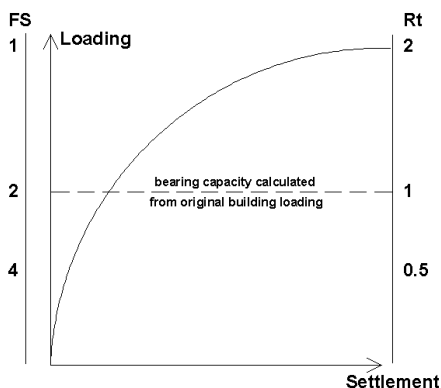


Figure 2. Reuse load factor R_t and factor of safety on the example of pile load test.

6 CONCLUSION

Reuse of foundation will be more and more in designers discussions in the future. The process of foundation design will affect the reuse of foundations especially in large cities. Increasing costs of materials and their transportation will push the designers reuse the existing foundations.

The main problem is usually lack of information about the original foundation structure. The best parameter seems to be parameter R_t . This parameter is based on the real observation and knowledge of the original forces is crucial for this option. This knowledge shall be done before the demolition of the original structure. Piles are usually possible to reuse. Nowadays construction of deep, large spread foundation of high buildings will be possible to reuse in the future for new building. The current design and construction process of new buildings shall be well and credible documented for future designers and reuse of current foundations in the future.

7 REFERENCES

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