THE RD – PILE SYSTEM

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ABSTRACT

The RD- micro pile system is a complete piling system for drilled steel tube piles with diameters from 90 up to 800 mm. The bearing capacity covers from 100 kN up to more than 10 MN. The system consists of

- high strength steel tubes
- top plate
- threaded pile splices
- pile toe drill bit

The paper gives a description of the system and applications where it is suitable. Some projects where the RD-pile system has been used are mentioned. Design practice for the system is outlined in design guides and tools available on Internet. The description of the RD-system and the design tools are believed to be very valuable for ISM-members when steel tube piles are considered.

INTRODUCTION

The RD pile system has been developed by the Finish Rautaruukki Corporation. Since the main target for the pile system is Scandinavian countries, it is geared towards point bearing piles. The dominating ground conditions in that region are very soft clay (undrained shear strength about 10 to 20 kPa) overlaying glacial till or bedrock. Thus, the RD-pile system is also suitable at other locations where similar ground conditions are found.

In Scandinavia, RD-piles and the Ruukki RR-piles are constantly increasing their share of the piling market. Today, around 40 % of the total volume of piles (about 2 million metes per year) installed are such piles. Main market extensions have been achieved where traditionally precast concrete piles have dominated.

DESCRIPTION OF THE RD-PILE SYSTEM

The main parts of the RD-pile system are:

- a tube of high strength steel
- a drill bit, which is also the pile point
- threaded pile splices
- a top plate (if required)

The tube is drilled down to a bearing level, usually a rock surface. Standard drilling equipment is used for this. After cleaning of the tube interior, the tube is filled with cement grout or concrete after validation of the bearing capacity of the tube. The latter usually made by dynamic load testing.

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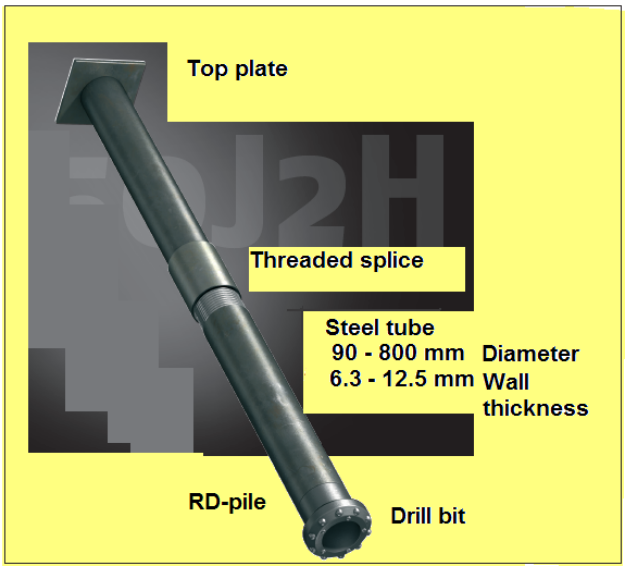

Figure 1. Components of the RD-pile system

The components of the RD-pile system are illustrated in figure 1. The RD-pile system and its components have been developed by the Rautaruukki Corporation and Tampere Technical University in Finland since around 1995. Before that, development of small diameter (70 – 90 mm) steel tube piles was undertaken in Sweden. However, the improvements were hampered by the dominating role of precast concrete piles.

One advantage with the RD-pile system is that the pile can be inspected in detail before it is approved for use. High quality demands are thus possible to meet. Drilling is an installation method not prone to unforeseen delays. This decreases the risk of costly deviation from piling project schedule to a minimum

The installation is made by relatively small sized equipment, possible to noise-protect effectively. The vibrations during piling are very limited. No lowering of the ground water table is required. These factors together make the RD-pile system very environmentally friendly compared to several other pile methods.

WHERE IS THE RD-PILE SYSTEM SUITABLE?

The RD-pile system is usually suitable where one or more of the following conditions for a pile project exists;

- obstacles for usual pile methods, e. g. boulders or manmade fill containing components difficult/impossible to penetrate by other methods than drilling.
- restrictions related to the environment ,as for example vibrations, soil movements and noise.
- large concentrated loads making high capacity piles suitable.
- no delays for the piling installation are acceptable.
- special demands for the installation are required, as for example piling close to existing piles and other structures embedded in the subsoil.

- no component containing cement is brought to direct contact with the soil or ground water surrounding the pile, preventing any related contamination of mentioned items.

FOUNDATION DESIGN USING THE RD-PILE SYSTEM

Acceptable tolerances for installation coordinates, deviation and slope for the RD-piles should be outlined before installation starts. Further, these tolerances must be known to the designer in order to make an optimal pile design possible.

For piles subjected to dynamic loads, e. g. machine foundations, critical frequencies must be calculated to provide a proper design of the pile-cap assembly.

REQUIRED PRE-PILING INVESTIGATIONS

There are a number of conditions which should be investigated before the RD-pile system is selected and design finalized;

- restrictions related to environmental conditions.
- levels and properties of soil/rock material at pile point level.
- soil properties around the pile (to evaluate the buckling load, mainly).
- accessibility and bearing capacity for the drilling equipment.
- ground water conditions.
- corrosion related conditions.
- existing objects which can be affected of the drilling, e g foundations and sever lines.

STANDARD DIMENSIONS

The standard dimensions of the RD-Pile System are illustrated in Table 1.

Pile type	Dimensions	Steel grade
RD90/6.3	88.9 x 6.3	S440J2H
RD115/6.3	114.3 x 6.3	S440J2H
RD115/8	114.3 x 8	S440J2H
RD140/8	139.7 x 8.0	S440J2H
RD140/10	139.7 x 10.0	S440J2H
RD170/10	168.3 x 10.0	S440J2H
RD170/12.5	168.3 x 12.5	S440J2H
RD220/12.5	219.1 x 12.5	S440J2H
RD320/12.5	323.9 x 12.5	S440J2H
RD400/12.5	406.4 x 12.5	S355J2H
RD500/12.5	508 x 12.5	S355J2H
RD600/12.5	610 x 12.5	S355J2H
RD700/12.5	711 x 12.5	S355J2H
RD800/12.5	813 x 12.5	S355J2H

Table 1. Standard dimensions of the RD-pile System (outer diameter/wall thickness, millimetres, S355 or S440 is steel yield limit in MPa. J2 means Sharpy tests made down to -40 degrees Celcius (required for bridge foundations, for example). H means “hollow”).

The large range of the dimensions available means that the optimal pile for every project can be selected. Tubes from 90/6 (outer diameter/wall thickness, millimetres) to more then 800/12.5 means a load range from 100 kN to more than 10 MN. The pile bearing capacity that can be used for a particular project is usually the lowest of the point bearing capacity and the buckling load.

Calculation of the bearing capacity can be made by information material issued by Rautaruukki Corporation, as for example a MS Windows based design application hosted at the Ruukki home page www.ruukki.com. There also compete drawings in AutoCad dwg-format for RD-piles can be downloaded, which is a great supporting feature at the design stage.

There is also a recent report, (Report #104), from the Swedish Pile Commission which gives guidelines and design tips aimed at designers as well as checklists and control specifications to be used at site installations of RD-piles. In Finland, there are codes issued by building authorities for the design, installation and quality control concerning RD-piles. These are also available in English.

STEEL MATERIAL FOR THE RD-PILE SYSTEM

The RD-piles are usually made by a Euro Standard steel classified as S355J2H, which means that the strength is 355 MPa, that the steel ductility has been tested down to -40 degrees Celsius (the 'J2'-term) and that it is a hollow section (the 'H'-term Rautaruukki Corporation can also deliver S440 and S550. Other high quality steel grades are X60 and X70, see Table 2.

	C [%]	Mn [%]	P [%]	S [%]	CEV [%]
S355J2H	0,22	1,60	0,030	0,030	0,39
S420MH	0,16	1,70	0,035	0,030	0,43
S440J2H	0,18	1,60	0,020	0,018	0,39
S550J2H	0,12	1,80	0,025	0,015	0,39
X60	0,15	1,60	0,030	0,030	0,43
X70	0,15	1,70	0,030	0,030	0,43

Table 2. Steel specifications for the RD-pile system

For pile dimensions up to RD 320 mm, the tubes are made by a longitudinal weld. For larger diameters, the weld making up the tube is a spiral one. The welding is made in the factory by an automatic procedure, meeting very high quantity standards.

Ruukki's steel pipe piles are made of cold formed welded structural hollow sections of non-alloy and fine grain steels.

DRILLING OF RD-PILES

RD-piles can be installed by most large diameter tube drilling technique. Top hammers or down the hole hammers (DTH) can be employed. Hammers can be air or water driven. The usual technique, at least for larger diameter RD-piles, is using a DTH-hammer and a ringset (centric drilling) at the pile point. A typical design of the connection between the ringset and the pile tube is illustrated in figure 2 below.

The RD-ringsets are designed to provide enough space for the threaded splices as well as giving a flat drill bit surface against the bed rock below the pile point. I should be mentioned that ordinary large hole drilling techniques, e g ODEX, are not primarily designed to function as a piling system. The RD-Pile System on the other hand, is a modification of existing drilling systems in order to be a dedicated drilled pile system.

Figure 2. Ringset at the point of a RD-pile, RD-270.

Further, there are recent developed/tested concentric drilling systems where there is no ringset attached to the pile point. Instead an extendable drill pilot device is used, with retractable extenders so that the tube lower point is brought to direct contact with the rock surface below.

RD-PILE SYSTEM SPLICES

One pronounced requirement from users has been to develop a splicing system where welding is not required. Therefore the RD-pile System splice (figure 3) was developed. Threaded sleeve splices are available up to pile dimension RR220/12.5.


Figure 3. The RD-Pile System threaded splice.

Avoiding welding in the field and at indoor confined locations is a big improvement for the conditions for the piling crew. There is no longer any need for specialized certified welders at the site. The quality of the splices is secured without the need of costly and time consuming testing. RD-pile splices have been subjected to a large number of tests, evaluating the capacity in compression, tension, bending, and fatigue
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VERIFICATION OF CAPACITY OF THREADED SPLICES

A large number of tests investigating the capacity of the threaded spliced in compression, tension and bending has been performed at the technical universities in

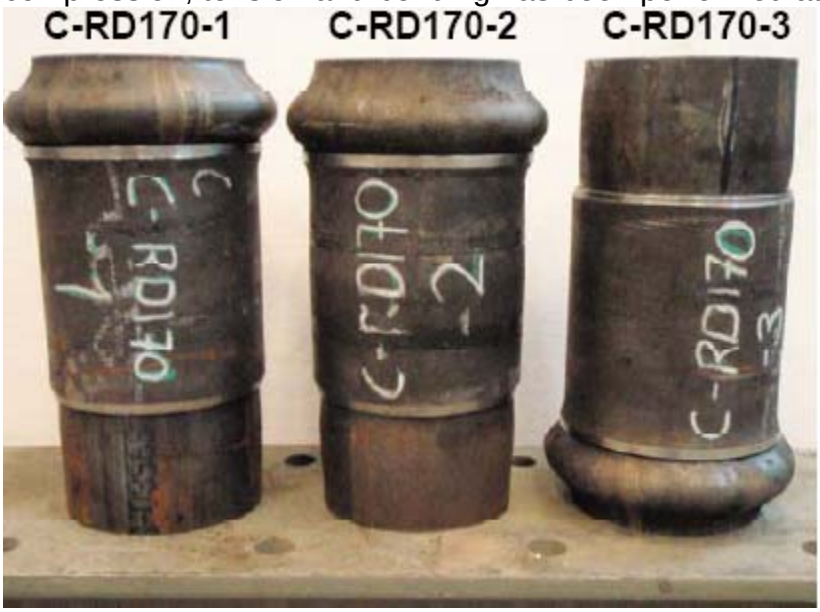

Fig 4. RD-pile splices tested to ultimate compressive capacity, RD170/10.

Tampere and in Stockholm, e. g. figure 4. The results from the tests are available at www.ruukki.com. The tests serve as a base for the road and railroad authorities to approve the splicing solution of the RD-pile system. The test criterion is in general that

the capacity of the spliced section shall not deviate significantly from the capacity for a tube section not spliced.

VERIFICATION OF GEOTECHNICAL BEARING CAPACITY

The rock quality may sometimes be difficult to evaluate during drilling. Therefore, the point bearing capacity is usually validated by means of dynamic test loading. The usual technique is to test the capacity of the drilled tube when drilling is completed. There has also been static test loading on RD-piles filled with concrete.

PROJECTS

The RD-Pile System has gained increased popularity among owners, designers and drilling contractors. Among other projects one can mention a large number of building and bridge projects in Sweden, Finland and Norway. The RD-pile system is approved for use by the Road and Railroad authorities in Sweden and Finland.

At www.ruukki.com there are several case stories described. Among other more recent projects where the RD-pile system has been used the following can be mentioned:

- Stockholm Central station, a new shopping centre built below the existing station
- Kvarnholmen City development project, RD270 and RD500 at waterfront
- Turku parking building, up to 60 m long RD500
- Route E6, West Coast Sweden, several highway bridges on RD-piles
- Waterfront structures at the Öresund ship reparation wharf, RD-piles + injected piles
- Finnish Rail Road Authorities, several build and push bridge projects
- and many more …

REFERENCES

1. www.Ruukki.com
2. www.bredenbergteknik.com