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Construction, Maintenance and Demolition of Nuclear Power Plants

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ABSTRACT

Hilti is your reliable partner in nuclear power plant construction, maintenance and demolition worldwide. Professional advice and innovative solutions for virtually every phase of construction and supply technologically leading products and systems to increase your productivity and help to create and maintain safe and lasting plants is offered.

The solutions for nuclear power plants construction, maintenance and demolition have been employed with great success in many different countries on a wide variety of projects due in no small way to their worldwide availability. An unbroken, international exchange of experience upholds a permanent innovation process. This assures our customers that they always receive products on the very latest technological standard.

This paper is not intended to cover all topics related to nuclear power plants. The idea is more to give a kind of an overview. The paper covers briefly the following topics: safety (corrosion and fire), fastenings, measuring and finally decommissioning of nuclear power plants.

1 INTRODUCTION

The expertise and know-how is based on decades of close customer contact, in-house research and development and intensive field testing. Every product manufactured complies with the strict international construction codes. Only the highest-quality materials are used for our products and we offer you all the help you need to choose the right system solution for your application at hand.

Hilti test series primarily focus on static as well as dynamic product loading and material testing. All requirements specified by development units are implemented during manufacturing as a result of our documented quality assurance system. Thus the customers can check the high quality standards at any time.

Fastenings in power plants are subjected to not only static but often also dynamic loads. During wide-scale, in-depth test series, the suitability of Hilti fastenings systems for dynamic loadings are investigated and professional solutions to identified problems are then developed. The fastenings are also subjected to shock loadings.

2 MULTI-LEVEL SUPPORT

Our clients expect multi-level support, all the way from planning phase right up to completion. The projects are managed better by:

- Providing application-focused technical advice and software
- Carrying out continuous on-site testing, training and demonstrations
- Giving the best benefits of superior jobsite logistics and outstanding repair services
- Ensuring conformity with specific application requirements.

Maximum safety and ease of planning, achieving the lowest possible emission values. Hilti knows what is required in the specialized field of nuclear power – all the way from initial construction to controlled demolition. Our network of experience sales representatives, field engineers, technical specialists and customer service representatives is there to serve you.

Time is money. An old adage perhaps, but is certainly holds true when it comes to nuclear power plant projects. Immense costs are incurred each day a reactor is not up and running and producing power. This is where our expertise and decades of experience certainly pay dividends. The items needed for each solution, each step to be carried out and the personnel and labour time required can all be calculated very precisely. Surprises are not part of the plan.

Time and time again, the clients are astounded by the ease with which seemingly unfamiliar and daunting tasks can be carried out thanks to Hilti, using well-proven, standard methods and products – reliably, safely and very quickly.

3 SAFETY

In the construction, maintenance and controlled demolition of nuclear power plants, the safety of people and the environment clearly comes first. Clients working on projects in this field can take full advantage of international experience and technical expertise that allow solutions to be adapted quickly and easily to meet individual requirements.

3.1 Corrosion

The resistance to corrosion of fasteners presents another major challenge. Constantly striving to supply technically superior fastening systems with components manufactured from the best grade of steel for each task, we have been carrying out weathering and exposure tests in corrosive environments for over 35 years. The types of steel tested include:

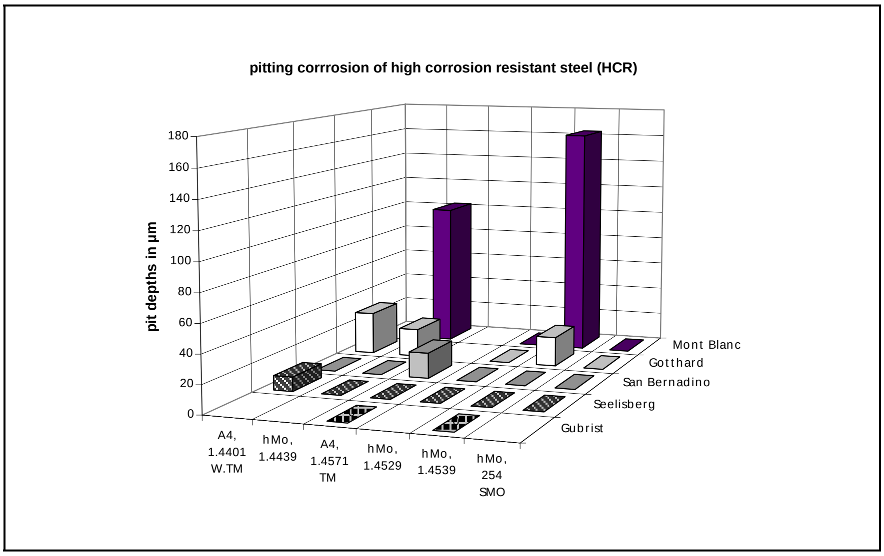
- Numerous carbon steels and stainless steels, including highly corrosion-resistant grades
- Titanium, aluminium and nickel alloys
- Samples from various manufactures
- Specimens in various forms and dimensions

Subsequent assessments include microscopic analysis and load tests for comparison with unweathered reference specimens of the same material. This work is supported by Hilti’s corrosion research laboratories, focusing on

- Simulating real application conditions (pollutants, temperature, humidity etc.)
- Accelerated corrosion testing

In-house competence is complemented by close cooperation with academic institutions including the ETH Zurich, Switzerland, Montan University of Leoben, Austria and the University of Stuttgart, Germany. These activities have yielded what is probably the world’s most extensive database on corrosion and corrosion-resistant fastening systems.

There are stainless steels and stainless steels. Even materials presumed resistant, like galvanised steel, A2 or A4 stainless steels and aluminium, rust in highly corrosive surroundings. The quality of fastenings also suffers. But, even in these conditions, HCR anchors do not corrode where other materials have long succumbed. The advantages are: high resistance to corrosion, high mechanical strength like A4 stainless steels, long life expectancy, specials and customised lengths on request, wide product programme (chemical and mechanical anchors), wide range of loading capacities, high safety level. See figure 1 for the difference in pitting corrosion of high corrosion resistant steel (HCR) compared with low alloyed stainless steel.



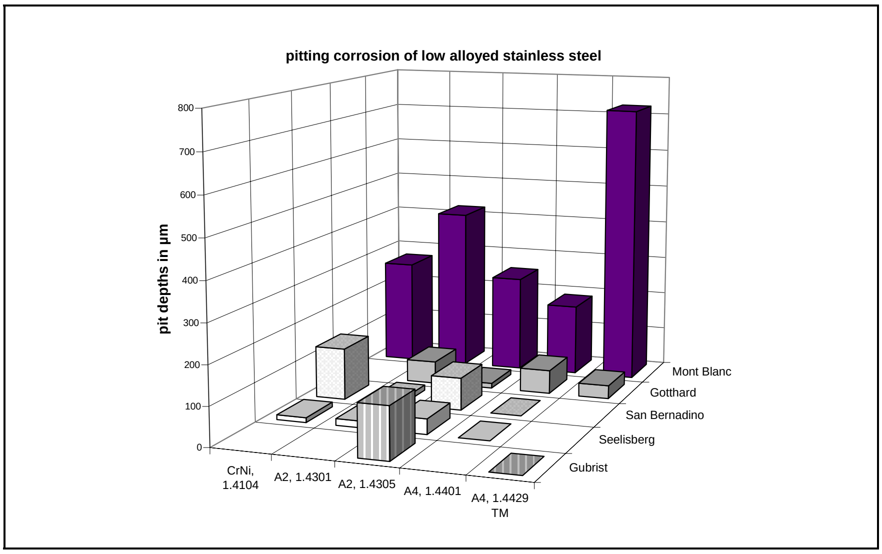


Figure 1: Pitting corrosion after two years of exposure

3.2 Fire

Hilti has gained decades of experiences in the field of passive fire protection, including:

- Protection of structural components
- Fire resistance of fastening systems
- Fire stopping at penetrations and construction joints

As a company we have long focussed on qualifying our fastenings products in terms of fire resistance. This includes mechanical and adhesive anchors, DX powder-actuated fasteners and channel installation systems. To facilitate the research work required for creation of an extensive knowledge base, the company set up its own furnace and testing facilities. Today we are a supplier of fire stopping products designed to close the gaps of all kinds in fire-rated structures, such as at service penetrations or building joints.

The expertise doesn't stop at the products supplied. Our clients benefit from true added value when reliable products are combined with the comprehensive knowledge of applications provided on site by our fire stop engineers. It is this focus on realistic test situations and the jobs to be carried out that provide real-life know how.

Penetration and opening in power houses and cable galleries through which flames, heat, smoke, fumes or gases could spread in the event of fire can be sealed off, by using Hilti fire stop systems to contain the fire and minimise damages. Tested fasteners for passive structural fire prevention can be used. The products range for passive fire prevention: fire stop sealant, mastic, cushion, plug, bricks, mortar and fire stop jackets.

4 FASTENINGS

Taking decades of dynamic loading in corrosive environments in their stride, fastening and installations systems have proved their superiority by ensuring maximum reliability in power plants around the world.

We offer a broad range of perfectly coordinated systems covering everything from straightforward fastening of infrastructure items such as electrical and mechanical components, hand rails or steps and stairs, right down to more demanding installation tasks such as the installation of cranes and turbines subject to high dynamic loads.

4.1 Shock, fatigue and vibration

As the world leader in fastening technology, with decades of experience, Hilti has developed an-depth understanding of dynamic loading situations in power plants and comprehensively investigated their impact on fastening solutions.

- Seismic loading during an earthquake
- Fatigue loading (e.g. anchors for pumps motors, turbines, HVAC equipment etc.)
- Repetitive shock loading (e.g. hydraulic equipment, water pipes etc.)

Testing is carried out at the main laboratory for dynamic anchor testing at our corporate headquarters in Liechtenstein (figure 2) – considered by many experts to be the world's most sophisticated anchor testing laboratories. Many international specialist and academic institutions make use our facilities in various forms of cooperation.

Our clients therefore benefit from exceptional competency, including detailed knowledge of anchor behaviour under dynamic loading. The test equipment is capable of subjecting test specimens to extremely high loads at high pulse frequencies and velocities. We have developed special measuring techniques to allow anchor loads to be analyzed with high precision. These techniques have been used in many projects where the dimensioning of anchors proved exceptionally difficult due to uncertainties regarding the expected load levels.

The loading history of structures and fasteners is of vital importance, especially where anchor systems are designed to withstand fatigue and shock loads. Critical loads usually occur only infrequently and unpredictably. To help provide a greater understanding of true loads over a period of time. Data is gathered in cooperation with the clients concerned, by installing measuring and recording equipment on structures in real-life situations.

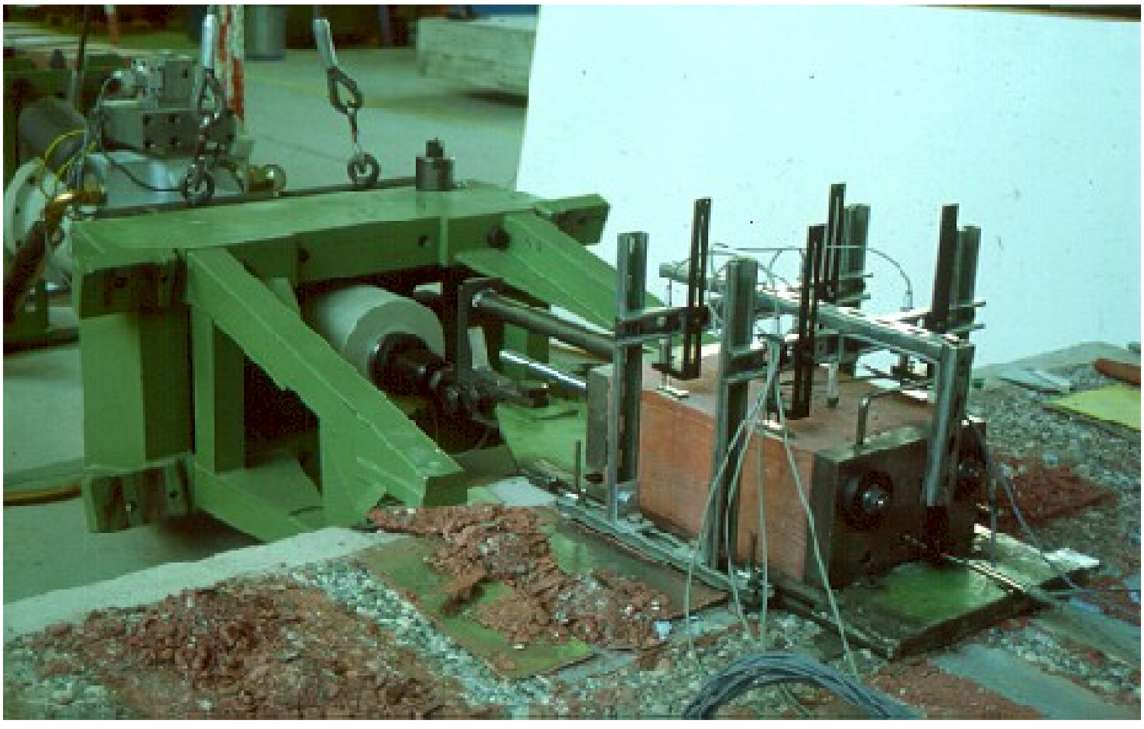


Figure 2: Laboratory tests by Hilti corporate research

4.2 Reliability engineering for fastenings

Modern structures, whether made of wood, masonry, concrete or steel, comprise interconnected parts. The connections take many forms. This paper deals with the following systems: chemical or bonded and mechanical anchors, furthermore, post-installed rebar with max. 10d embedment.

Mechanical anchors are set in a drilled hole. These systems use a cone to expand a sleeve at the tip of the anchor. The expansion produces either friction against the wall of the concrete hole or an undercut to retain the anchor by keying (figure 3). Bonded anchors and post-installed rebars are also set in drilled holes. A bonding agent fixes them into the bore hole (figure 4).

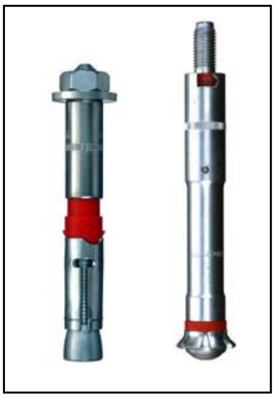


Figure 3: Mechanical anchors

Figure 4: Post-installed rebars

Under tensile loads, fastenings will fail either by yielding of the steel, by being pulled out of the concrete hole, by breaking a cone out of the concrete base material, or by splitting the concrete in case of low distances to the concrete edge or low spacing between fastenings. A very rear and for ETAG approved anchors not possible failure mode the side-face blow-out is also possible with small edge distances, mainly for undercut anchors.

Under shear loading, the yielding of anchor steel, steel yield under the effect of high shaft bending, the concrete edge failure, the pry-out failure are the typically investigated most likely failure modes.

It is often forgotten, that the anchor plate is acting between the concrete and the structural element as a connector. A control of the connecting plate should always be part of fastening design. To deliver reaction forces in the individual anchors for the anchor design, normally a rigid plate is required according to the various codes. It must be added that there is no definition of that “rigid plate” according to any code is available yet, so designers must rely on other structural codes, various company solutions (like Hilti`s) or on their personal experiences.

4.2.1 Fastening design concept

The design of concrete structures has considerably evolved over the last two decades. The basic research aiming at a probability based design has led from global safety factors to concepts with standardized partial safety factors [1]. Fastenings, as an integral part of structures, have followed this development.

Global Safety against Mean Ultimate Loads: This concept has the advantage of being very simple and straightforward. The mean failure value from a number of tests is evaluated and then divided by a safety factor. This factor depends on the experience available with the tested system and from the observed scatter in the testing. This procedure is mainly used with systems for which there is no standardized evaluation and design procedure yet. ICBO evaluation reports define the admissible load of adhesive anchors as the mean ultimate value divided by a safety factor of 4.0 [2].

Global Safety against Characteristic Loads: While the above concept is very easy to use, it is often preferable to refer to a defined minimum value. In fastening technology it is usual to evaluate the 5%-fractile with a confidence ratio of 90%. In anchor testing a normal distribution of the loads is assumed and the coefficient of variation is usually between 10% and 20%. Safety factors range from $\gamma = 5$ for light duty plastic anchors to 2.5 for sophisticated, reliable high strength anchors. This was the standard safety concept for anchors until recently and is still in use with well-established anchors for which no re-evaluation according to new standards has been made.

Partial Safety Factors: New anchors are evaluated, approved and designed according to safety concepts with partial safety factors. In the following, the design concept according to [3] is briefly shown for anchors under tensile load. For the design of fastenings the safety concept according to [4] is applied. According to this concept, the values of the design actions S_d should not exceed the value of the design resistance R_d.

$$S_d \leq R_d \tag{1}$$

In the ultimate limit state of resistance, the value of the design resistance, R_d, is obtained from the characteristic resistance, R_k, of the anchor by dividing it by the partial safety factor for material γ_M:

$$R_d = R_k/\gamma_M \tag{2}$$

The partial safety factors for actions depend on the type of loading and should be taken from the valid code.

The material safety factors given in the following are valid for safety class 2 [1]. Factors for safety classes 1 and 3 should be determined according to the national guidelines.

If there no specified factors for a given anchor, the partial safety factor for concrete cone, splitting and pull-out failure, γ_{Mc}, may be defined as follows:

$$\gamma_{Mc} = \gamma_C \cdot \gamma_1 \cdot \gamma_2 \tag{3}$$

with

γ_C standard partial safety factor for concrete (=1.5)

γ_1 takes into account additional uncertainties for concrete under tension (=1.0 to 1.2)

γ_2 takes into account the uncertainties due to anchor installation (=1.0 for systems with high installation safety, =1.2 for systems with normal installation safety, =1.4 for systems with low, but still acceptable installation safety)

The partial safety factor for steel failure may be taken as γ_{Ms} = 1.2 [3] or from the relevant code.

Comparison of Governing Actions: A typical load case is selected with 2/3rd of the load is so called “Dead load” and 1/3rd of the load is “Live load” of the unit load. The ETAG then would apply an average 1.35*2/3+1.5*1/3=1.4 as resulting load. The Socotec method in France identifies “Short term loads” like high wind or earthquake with load factor 1.75, which is in this case to keep the example simple, equal to zero. So 1.35*2/3+1.5*1/3+1.75*0=1.4. In Europe according to the partial safety concept this sum is called the “design load”, which is the “load factor” multiplied with the “characteristic load”. Let’s call this process the Partial Safety Factor Design (PSFD).

The American ways: for “Strength Design”, which accepts 11 different load types and with these loads 14 different load combinations are generated. The governing load case is, which results in the highest anchor forces. It is obvious that it is an extremely work intensive design method. According to the Strength Design the governing load case would be for the selected example: 1.2*2/3+1.6*1/3=1.333. The method ACI 318 with AC193 approval is using such a Strength Design load combination. The load cases are also called as Load and Resistance Factor Design (LRFD). The Allowable Stress Design (ASD) methods use roughly 10 different load combinations of the 11 same different load types. Our design example would be 1.0*2/3+1.0*1/3=1.0 - the unit load.

The 3 PSFD methods are using very similar governing or design loads: 1.33 to 1.4, with a difference of 5%. It can be stated, that they are statistically identical. This design or governing load case (S_d) is then compared with the design resistance (R_d) in Eq.(1). The governing or design load is a fictitious, statistically verified load, which is for every day use often falsely simplified as “Recommended Load”. The recommended load of a PSFD is the design resistance divided by the load factor. In Hilti practice a single load factor of 1.4 is used world wide based on Eurocode.

The load input of ASD is something very different so the presentation of the “design resistances” with which the loads are compared. The highest load an anchor carries safely is then called “Allowable Load” and ASD method reduces the anchor resistance to comply statistical safety. A direct comparison between ASD and PSFD-LRFD methods is not possible and the interpretation of technical data coming from the two different environments is extremely difficult. This causes often problems especially for engineers in a third country who actually familiar with none of the above methods and approval processes. Just the terminology of the different methods is confusing enough.

Based on the above example it can be said, if the identical anchor is examined the ratio of “Design Resistance” to “Allowable Load” (PSFD to ASD) is roughly 1.4. To achieve an adequate anchor performance with the required safety the ratio of actual applied load to anchor statistical resistance, which if tested properly can not possibly be any different according to the different methods.

4.2.2 Effects of design concepts on fastening technology

At this time all design concepts mentioned above are in use. The valid design concept directly influences fastening technology as well in terms of admissible loads as in terms of anchor sizes. The following paragraphs will show this for mechanical anchors and for post-installed rebars. All comparisons will be made on the level of admissible loads.

Post-installed rebars

Concrete cone failure is critical for bonded anchorages with low embedment depth. Since post-installed rebars have minimum embedment depths of at least 10 times the rebar diameter ϕ, only pullout and steel failure will be considered in this comparison. The mean value of pullout failure $N_{p,m}$ [N] can be calculated assuming a uniform bond stress along the rebar [5]:

$$N_{p,m} = \tau_m \cdot \phi \cdot \pi \cdot h_{ef} \tag{4}$$

with τ_m average bond stress at failure [N/mm^2], h_{ef} effective embedment depth [mm]

Steel failure will occur at

$$N_{s,m} = f_y \cdot A_s \tag{5}$$

with f_y yield strength of steel [N/mm^2], estimated coefficient of variation 3%

A_s nominal cross section of steel [mm]

The basic anchorage length l_b of a given rebar is defined as the anchorage length, at which both, pullout and steel failure are expected at the same load level. It is obtained by equating expressions (4) and (5). Comparing mean ultimate loads, $l_{b,m}$ is:

$$l_{b,m} = \frac{f_y \cdot A_s}{\tau_m \cdot \phi \cdot \pi} \tag{6}$$

The corresponding admissible load with a global safety factor against mean values γ_m is

$$N_{adm,m} = \frac{f_y \cdot A_s}{\gamma_m} \tag{7}$$

The characteristic loads, as defined in fastening technology, are calculated by multiplying the mean ultimate loads by a factor of $(1 - k \cdot \mathrm{cov}_M)$, where k=1.645 and cov_M is the coefficient of variation of the failure loads (cov_p for pullout and cov_s for steel failures). Division by a global safety factor against characteristic loads γ_k yields the admissible load $N_{adm,k}$.

$$l_{b,k} = \frac{f_y \cdot A_s}{\tau_m \cdot \phi \cdot \pi} \cdot \frac{1 - k \cdot \mathrm{cov}_s}{1 - k \cdot \mathrm{cov}_p} \qquad N_{adm,k} = \frac{f_y \cdot A_s \cdot (1 - \mathrm{cov}_s)}{\gamma_k} \tag{8}$$

With the partial safety factors concept with a single safety factor for loads γ_L, the basic anchorage length and admissible load become

$$l_{b,p} = \frac{f_y \cdot A_s}{\tau_m \cdot \phi \cdot \pi} \cdot \frac{1 - k \cdot \mathrm{cov}_s}{1 - k \cdot \mathrm{cov}_p} \cdot \frac{\gamma_{Mc}}{\gamma_{Ms}} \qquad N_{adm,p} = \frac{f_y \cdot A_s \cdot (1 - \mathrm{cov}_s)}{\gamma_{Ms} \cdot \gamma_L} \tag{9}$$

Table 1 shows the numerical values obtained for mean values and standard deviations usually encountered in pullout testing of rebars set with the Hilti HIT HY 150 mortar. The safety factor for steel corresponds to Eurocode 2 and the material safety factor bond to concrete γ_{Mc} is that usually applied for such systems.

Table 1: Basic anchorage lengths and admissible loads for post-installed rebars

rebar diameter Φ [mm]	global safety factors vs. mean ultimate loads		vs. characteristic loads		partial safety factors vs. characteristic loads	
	$l_{b,m}$ [mm]	$N_{adm,m}$ [kN]	$l_{b,k}$ [mm]	$N_{adm,k}$ [kN]	$l_{b,p}$ [mm]	$N_{adm,p}$ [kN]
10	95	10.5	119	13.2	224	24.6
16	151	26.8	191	33.8	359	62.9
25	237	65.3	299	82.4	561	153.6
40	379	167.2	478	211.0	897	393.3
Assumptions:	τ_m = 14 N/mm^2 f_y = 530 N/mm^2	cov$_p$ = 0.15 cov$_s$ = 0.03	γ_m = 4.0 γ_k = 3.0		γ_{Ms} = 1.15 γ_{Mc} = 2.1	γ_L = 1.4

Mechanical anchors

Pullout failure of mechanical anchors may be prevented by appropriate construction. In this case only concrete cone and steel failure are critical. The mean value of concrete cone failure $F_{c,m}$ [N] is usually expected at [6]

$$F_{c,m} = 13.5 \cdot h_{ef} \cdot \sqrt{f_{cw,m}} \tag{10}$$

with h_{ef} effective embedment depth [mm], $f_{cw,m}$ cube strength of concrete [N/mm^2]

Steel failure is defined by equation (5), while here, A_s is the decisive cross section of the anchor rod. The optimum use of the anchor steel is given if both critical failures are expected at the same load level. The corresponding anchorage length $h_{ef,opt}$ is obtained by equating expressions (10) and (5).

$$h_{ef,opt} = \left(\frac{f_y \cdot A_s}{13.5 \cdot \sqrt{f_{cw,m}}} \right)^{2/3} \tag{11}$$

The expressions for admissible load and the corresponding values for characteristic loads and partial safety factors are obtained by the same procedure as equations (7) to (9). Table 2 shows the numerical values obtained for mean values and standard deviations usually encountered in pullout testing of heavy duty anchors. The safety factors are taken from [CEB]. The steel corresponds to an 8.8 quality and the average compressive strength of the concrete of 35 N/mm^2 would lead to a C20/25 according to Eurocode classification.

Table 2: Optimum anchorage lengths and admissible loads for mechanical anchors

Anchor size	A_s mm^2	global safety factors vs. mean ultimate loads		vs. characteristic loads		partial safety factors vs. characteristic loads	
		$h_{ef,opt}$ [mm]	$N_{adm,m}$ [kN]	$h_{ef,opt}$ [mm]	$N_{adm,k}$ [kN]	$h_{ef,opt}$ [mm]	$N_{adm,p}$ [kN]
M10	58	62	11.9	73	15.0	96	22.3
M12	84.3	80	17.3	94	21.8	123	32.4
M16	157	121	32.2	142	40.6	186	60.4
Assumptions:		$f_{cw,m}$ = 35 N/mm^2 f_y = 680 N/mm^2	cov$_p$ = 0.15 cov$_s$ = 0.03	γ_m = 3.3 γ_k = 2.5		γ_{Ms} = 1.2 γ_{Mc} = 1.8	γ_L = 1.4

For a design example the reader is referred to [7].

4.2.3 Results

The comparisons have evidenced the advantages of partial safety factor design concepts over global safety design for fastening systems. The different materials involved in fastening technology, i.e. steel, concrete under tensile stress and bonding agents differ greatly in their scatter. Since they can now be designed according to their true characteristics, much higher loads may be obtained with a given anchorage. Nevertheless, it appears clearly, that higher loads have to be paid with deeper embedments.

It is current practice of internationally operating companies selling fastening elements to show technical data outside of the engineering culture, which uses and understands them. It has been shown that the interpretation of such technical data is outmost difficult as the load input system of the different methods are matched with the calculation of the fastening resistance and the terminology of the methods are often confusing (e.g. resistance is referred as load).

With simple but detailed examples it was shown how methods can be compared to get a valid basis of comparing different products coming from different countries and tested according to different methods. (European “Design Resistance” is comparable with the “Allowable Load” from America). It is also clear that no matter what method is used the different engineering for the same product normally result in a more or less identical risk taking world wide, meaning that the usage of the fastening (load/resistance) is the same under the “same load”. We learned that this “same load” for the different methods is a key of the valid comparison and it is actually differs from method to method.

5 MEASURING

Hilti measuring tools make distance measuring, levelling alignment and detection easier, much faster and more accurate.

- At the touch of a button: distance measurement with laser precision for lengths, areas and volumes combined with practical calculation functions.
- Alignment work and transferring right angles are traditionally difficult and time consuming jobs that usually require two or more people. Now, they can be easily carried out by a single person in a fraction of the time.
- Detecting rebars saves wear and tear on the tools and drill bits and avoids potentially costly repairs. Detection tools locate rebar easily and reliably in a matter of seconds (figure 5).

Figure 5: Location detection of rebar

5.1 Constructions of nuclear power plants

Checking rebar layouts and minimum concrete coverage is necessary to determine whether the structure is safe and complies with the structural design and specifications. Rebar layout and spacing determines the actual strength of reinforced concrete elements. Concrete cover serves to protect steel reinforcement from corrosive elements and from heat in case of fire. When drilling or coring into reinforced concrete, it is important to avoid hitting and cutting rebar. Designing engineers for nuclear power plants also check as-built dimensions and verify tolerances for safety reasons.

The only traditional method of determining concrete coverage or checking tolerances is destructive testing – to physically chisel away the concrete until the rebar is located and then measure the depth. Only small sample areas can be tested in this manner. Dimensions would normally be checked by two people using a measuring tape.

The measuring systems result in:

- Time savings in detecting rebar in concrete and checking coverage.
- Non-destructive, reliable detection eliminates damage to concrete surface.
- Time savings in – and only one person needed for – checking dimensions and tolerances.

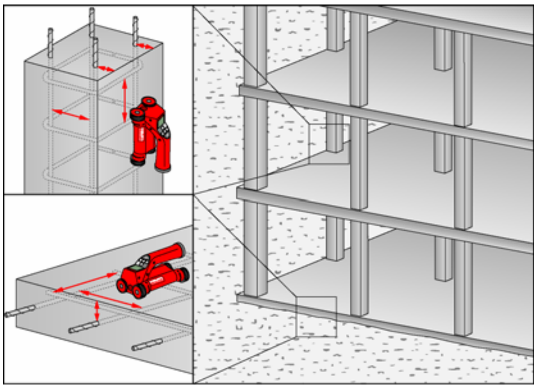


Figure 6: Checking cover and rebar layout

Checking cover and rebar layout (figure 6). Place the scanner on the surface of the concrete element and start scanning. Determine and mark the rebar locations. Check the minimum coverage and spacing of rebar, making sure that is complies with the design specifications.

Location rebar before drilling. Place the scanner on the surface of the concrete. Begin scanning, marking detected rebar as you go. In this way, safe areas for drilling can be determined.

Checking as-built dimensions and tolerances. Measure distances (lengths, widths, heights, thickness) with a laser range meter and compare the results with the plans. Measure sags of ceilings, openings (variations), and other important dimensions to check whether they are within specified tolerances.

Anchors can be positioned and aligned accurately with the aid of highly advanced precision laser and scanning system. Hazardous emissions during subsequent hammer drilling or diamond coring can be virtually eliminated before the straightforward installation of heavy-duty anchors for permanent, reliable fastening of the applicable components.

5.2 Installations for nuclear power plants

Before installing pipes, through holes and pipe rings need to be properly aligned, according to whether pipes run horizontally, vertically or sloped for drainage. After checking if anchor holes or wall penetrations can be drilled, measuring the anchor points takes place and pipes can be easily mounted with no further adjustment or rework. For heating and air conditioning, volumes of rooms need to be calculated to specify the size of ventilation equipment required including ventilations pipes. Heating, industrial equipment and sanitary elements are then installed at specific locations and levels and therefore need to be set at the same height.

The traditional measuring tools needed for mechanical installation work are a measuring tape, plumb bob, spirit level, water level, chalk line and square. Many tasks often require two or more people.

The measuring systems result in:

- Time savings for alignment, measurement and detection tasks.
- Only one person is needed for these applications.
- Safer and faster transferring of points from floor to ceiling.
- Non-destructive, reliable detection of rebar and copper pipes eliminates damage to finished surfaces as well as costly repairs.

Vertical alignment of pipes. Place the rotating laser on the floor and align with the desired location for installing the pipe. Mark the fixation points for installing the pipe along the desired wall or ceiling. Install the pipe rings and pipe. A rotating laser is used for medium to long range pipe installations.

Pipe layout and installation. Measure and mark the pipe layout on the floor (anchor points). Place the point laser on the fixing points and install the pipe hangers at the points transferred to the ceiling. Mount the rotating laser so that the beam is level with the first pipe hanger. If a slope is needed, measure the drop or rise over a distance. Align the laser beam with the desired slope angle. Cut the pipe hangers to the marked length and install the pipe rings.

Measuring offset distance. The clearance between the pipe and the ceiling is the difference between the height from the floor to ceiling and that to the pipe plus the pipe diameter.

6 NUCLEAR POWER PLANT DECOMMISSIONING

Professional support from experienced engineers for the planning of projects has made our company the preferred contact when it comes to nuclear power plant decommissioning. We are your partner in everything from the recommendation of working methods and provisions of advice on selection of the ideal tools and machines for the job, through to assistance with project-related time and cost calculations or even the construction of specially-designed rigs or individual adaptation of standard equipment.

When the equipment is put into service, out technicians are on the spot to provide technical advice and in-depth training. After this initial introduction, users of the world renowned, low-maintenance tools and machines know not only how to use the equipment most efficiently, but also how to look after it and how to carry out basic troubleshooting procedures. The accredited service technicians, qualified in radiation protection measures, are on call to carry out virtually all repairs on site, whenever necessary.

Our products and systems are, in many ways, technologically ahead of their time. In addition to supplying the best equipment for the job, we offer a range of unique services specially tailored to the demanding requirements of our nuclear power plant decommissioning.

6.1 Dry coring

Dry coring in reinforced concrete. The Hilti DD 200 diamond coring rig and Hilti PCC dry-cutting core bits featuring PCD (polycrystalline diamond) segment technology:

- Easy, cost-efficient disposal of contaminated concrete dust
- No uncontrolled contamination caused by water or concrete slurry
- Higher coring performance than core bits with conventional diamond segments
- Only one core bit specification for various types of concrete

6.2 Dry wire sawing

Dry wire sawing through steel and reinforced concrete with the Hilti DS-WS 15 diamond wire saw cutting through reinforced concrete:

- Steppless drive control for optimum cutting speed
- Pneumatic advance control for smooth operation and greatly reduced stress on the diamond wire
- Easily adjustable high-grade wire guide pulley system
- High-performance diamond wire for dry cutting

6.3 Surface decontamination

Hilti DG 150 hand-held diamond grinder and Hilti VCD 50 dry vacuum cleaner:

- Exceptionally rapid dust remover thanks to perfect system performance. Suction rate: 30 litres/ sec.
- Brushless SR motor technology for ten times longer lifetime compared to conventional grinding systems
- Removes concrete surfaces up to three times faster compared to conventional grinding systems. Removal rate approximately 50 cm^3/minute.

6.4 References decommissioning

Two references in this area will be discussed in the following part. For more references the reader is referred to [8].

Demolition of old retaining wall, Nuclear Power station in Chernobyl, Ukraine.

The project (2006-2007):
4th reactor of Chernobyl nuclear power was exploded on 1986. For erecting new nuclear sarcophagus, demolition of old retaining wall required.

Figure 7: Demolition of old retaining wall

Client:
UkrTransBud Corporation

Challenge:
The volume of heavily reinforced concrete for demolition is 3’150 m^3. High level of radioactivity requires fast workflow with minimum handwork. Due to radioactivity contamination any possible repair of the equipment may be allowed only on job site (no returns to service centre allowed).

The solution:
Hydraulic disk saw D-LP32 with 1600 mm saw disk

Figure 8: Hydraulic disk saw D-LP32 with 1600 mm saw disk

Benefits to the client:

- excellent reliability
- minimal human efforts
- high productivity means minimal radiation dose to workers
- operator remote workplace guarantee minimal dust inhalation
- full support – calculations, training, remote consultation.

Nuclear Decommissioning, SICN building, Annecy, France.

The project (2006):
Dismantling of SICN building Annecy (Haute Savoie)
Extraction of existing screw anchors to check the level of contamination

Client:
SICN /STMI AREVA Group

The challenge:
Extraction of anchors by dry core drilling
Core drilling to diameter 102 mm for insertion of a probe (diameter 92 mm) in order to check the contamination in the anchor location

Figure 9: Complete DD200 for dry core drilling

The solution:
Complete DD200 for dry core drilling + 52 PCC 102/600 core bits mounted on a trolley manufactured by the client and coupled with an absolute filter vacuum cleaner (100% dust recovery)

Benefit to the client:

- 100% recovery of dust
- No cooling water allowed as this would be contaminated
- Manoeuvrability of the system because mounted on castor roller trolley
- Speed of operation
- Accessibility in corners (trolley with rounded edges allowing mounting of the DD200 and drilling in corners)

Figure 10: Extraction of existing screw anchors

7 CONCLUSIONS

A broad selection of compatible fastening and installation systems for nuclear power plants (heating, air-conditioning, power supply, safety, ventilation equipment, etc) round off what is probably the most complete program of fastening systems on the market today. This is complemented by an extensive range of advanced fire stop products specially designed to ensure added safety in the various selections of nuclear power plant buildings and facilities. Different systems for decommissioning of nuclear plants finally round off the broad portfolio of systems and applications in the demanding field of nuclear power plants.

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