UNDERCUT PANEL ANCHORS FOR CONCEALED FASTENING OF CERAMIC CLADDING PANELS

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Summary

Fasteners for concealed fastening of cladding panels are opening up new architectural design possibilities for the most different types of facades. A high quality of performance - which is required for a material such as ceramics - is achieved by the factory-produced drilled holes and the type of fastener. The change from the currently used handicraft type of execution to an industrial production of ceramic facades offers economical advantages, for example as a result of different assembly procedures and prefabrication in segments.

1. Introduction

Exterior wall claddings using panels of ceramic materials have gained importance in Europe because of their visual and representative design possibilities. Features such as color fastness and frost resistance, resistance to environmental pollution, result in extremely low maintenance and care requirements, at the same time providing a highly expressive appearance. Especially the design of the exterior wall cladding as a ventilated, thermally insulated curtain wall satisfies both the esthetical and functional requirements of modern building.

Exterior wall claddings with panels of ceramic materials placed in a mortar bed may lead to problems, e.g. due to inevitable temperature stresses. The cladding panels and the structure to which they are attached by mortar have different thermal expansion coefficients, resulting in cracking of the exterior wall cladding. Moisture can penetrate through these cracks and the mortar joints (which are not always filled properly) to the rear side of the cladding panels and may lead to spalling after some time.

The principle of ventilated exterior wall claddings is to form a cavity between the structure and the cladding panel by mounting a subframe (see Figure 1). With «ideal ventilation», outside air conditions prevail in this cavity which, taking into account any thermal insulation, is also called a ventilation space. Moisture diffusing out from the structures is discharged by the air flow.

In the past, ceramic cladding panels used to be fastened to the subframe mainly by means of visible holding clamps. Even if these clamps are powder-coated in a durable manner in the color of the cladding

panel, they are thought to «interfere» with the visual appearance by some facade designers (see Figure 2). In the course of time, an increased accumulation of dirt can be observed around the holding clamps.

It has therefore been a request of facade designers for a long time to have an «invisible» connection between the cladding panels and the subframe. fischer has met this request in a very simple manner with its newly developed undercut panel anchor.

2. The concealed fastening system

2.1 The undercut panel anchor

In the course of development of undercut systems for anchoring in concrete, the idea came up to also use this anchoring principle for fastening of thin cladding panels. This principle is based on a drilled hole having a larger diameter inside the panel than at the panel's surface. fischer developed a drilling method for this by which an undercut hole (see Figure 3) is produced which is adapted to the undercut panel anchor. A special diamond drilling method ensures that the structure of the ceramic panel is not disturbed, e.g. by the formation of hairline cracks. The undercut panel anchors are then inserted into the holes drilled by this method on the rear side of the cladding panels and anchored in a stress-free manner. The cladding panel is therefore not stressed by expansion and prestressing forces during installation which are apt to cause damage to ceramic materials.

The undercut panel anchor designated FZP 11x7 M6 K, which is shown in Figure 4, consists of a taper bolt with male thread size M6 and a spreader ring, both of stainless steel (A4), and a hex nut of aluminum. To compensate for irregularities and hole tolerances, a plastic shim is fitted between the hex nut and spreader ring. This shim also seals the drilled hole so that no moisture can penetrate; this is particularly useful for the highly brittle ceramic material and the possibility of freezing water during the winter season. The materials selected for the loadbearing parts of the undercut panel anchors (stainless steel and aluminum) guarantee a long life of this fastener over the life expectancy of the exterior wall cladding into which they are installed.

The external stress acting on the taper bolt, caused by the dead weight of the panel and the wind load, is transferred into the panel material around the drilled hole via the «tripod»-shaped support provided by the garland-type spreader ring. This provides a cardanic support of the taper bolt in the cladding panels, thereby obtaining the maximum physically possible break-out force.

The connection to the subframe is usually made using a clasp (see Figure 5) or a panel supporting section screwed to the taper bolt. As this connection system is propped against the hex nut on the taper bolt, no additional forces are transferred into the cladding panel when the components are screwed to the undercut panel anchor.

2.2 The drilling process and installation procedure

The hole for the undercut panel anchor is drilled using a water-cooled diamond drill. A diamond-charged profile drill bit with inside bore is used for this purpose which, being a system component, is designated undercut panel drill. Stationary semi- or fully automatic drilling and setting equipment - which is part of the undercut panel anchor fastening system - is used almost exclusively for hole drilling and installation of the undercut panel anchors into the cladding panels. Figure 6 shows a stationary drilling machine which can be fitted up to numerical control, ensuring proper drilling of the undercut holes by its integrated control device. The cladding panel is placed against a stop, clamped on the supporting table and drilled automatically with an accuracy of ± 0.5 mm between holes. Different from this, the undercut holes are drilled manually with the stationary drilling machine with panel centering shown in Figure 7. The

undercut panel anchors are then installed in the undercut holes using a mounting device. An extremely high quality of performance, as well as a high level of prefabrication are achieved by drilling the holes and installing the anchors in the factory.

If fitting panels that have to be cut to size on the construction site are required for a project, the undercut panel anchors are installed in these panels by means of a mobile drilling and setting machine (site machine, see Figure 8). In this case, the cladding panel is sucked to the supporting table at the planned drilling position by a vacuum pump, and the hole is drilled manually with this drill. This is followed by installation of the undercut panel anchors using the mounting device fixed to the supporting table.

The process of drilling and subsequent installation of the undercut panel anchors in the cladding panel is shown in Figure 9. A cylindrical hole is drilled into the cladding panel by lowering the undercut panel drill. The hole depth is precisely maintained by a bit stop resting on the cladding panel. Then the undercut is produced automatically or manually by radial movement of the undercut panel drill. When both the pivoting angle and the resulting undercut size are preset by the machine, this undercutting process is carried out compulsorily .

Upon completion of the drilling process, the undercut panel anchor is inserted into the hole and the spreader ring is expanded by applying a torque to the hex nut. The undercut panel anchor is installed properly when the specified torque has been applied for tightening of the nut. The undercut panel anchors set in this way are fastened in the cladding panel without stress and can therefore carry high loads, despite their low anchoring depth.

2.3 Performance data and tips for designing the facade system

The attainable load-bearing capacity is certainly a function of the ceramic structure. It is however clearly higher than the break-out forces of the holding clamp fastening method. Thus, for example, a break-out load with centric tension of approx. 2.5 kN /1/ can be achieved with the undercut panel anchor FZP 11 x 7 M6 K at an anchoring depth of 7 mm in a ceramic panel of fine stone material produced by a dry process which has a bending tensile strength of 35 N/mm^2. With shear loading, a breaking load of up to approx. 4.7 kN /1/ is obtained, depending on the distance of the undercut panel anchors to the panel edge. Structural tests on facades with a size of several square meters have shown that the cladding panel itself or the subframe fail when loaded, but not the undercut panel anchor.

In designing the facade system, it has to be taken into account that the cladding panels are joined to the subframe without stress. This is achieved by fastening each panel with four undercut panel anchors, with one undercut panel anchor being joined to the supporting sections as a fixed point via the connector (e.g. clasp) and the three other anchors as sliding points (see Figure 10). This offers the possibility that the cladding panel can move in its plane relative to the subframe when temperature changes occur. Outer dimensions of 60 x 60 cm are regarded as the upper limit of the cladding panel size, and the panel thickness should not be less than 10 mm.

The wind suction load acting on the cladding panel is transferred into the subframe as a tensile stress via the undercut panel anchors and the connector fastened to the same. In the case of a wind pressure load, the wind load is transferred into the undercut panel anchor as a compressive stress acting on the hex nut via the shim.

The subframe for a ventilated exterior wall cladding should be designed so that a regular external appearance of the facade is obtained, even if there are irregularities in the base surface and manufacturing tolerances. This may, for example, be accomplished by means of the adjustment capability between wall fastener and vertical supporting section, or by the sliding capability of the clasp along the horizontal supporting section and the adjustment capability within the clasps (see Figure 11). The design of the facade

by means of clasps fastened individually to the cladding panel further offers the advantage that damaged panels can be removed separately from the facade and replaced by new ones. Normally, the joints between the individual cladding panels are left open, but it is also possible to insert joint sealing strips to keep out driving rain.

For the evaluation of the facade systems always the whole construction (consisting of ceramic cladding panels, undercut panel anchor and subframe) in view of the external influences (temperature and wind load) is decisive.

3. European directives for use

At the end of 1988, the European Community passed and published the so-called «Building Products Directive» for the building industry /2/. This directive dictates major requirements on building and civil engineering structures in the form of defined goals and objectives. This means that products used for building must be developed and produced in such a manner that they can be permanently installed in building and civil engineering structures. Finally, the directive also contains a regulation to coordinate technical specifications by means of a certificate of conformity, which can be a harmonized European standard or a European Technical Approval (ETA) as shown in Figure 1. This conformity, designated as a «presumed conformity with national law of European origin», is documented by the CE symbol to be applied directly to the product or packaging.

The member states of the European Community are granted a period of 30 months in the «Building Products Directive» to incorporate the objectives of the directive in their national legislation, thus adopting them in a legally binding manner for each state. The objectives of the European Community will thereby become «National law of European origin». None of the member states had made this adoption until the target date end of June 1991. With only two exceptions, all EEC member states had however enacted the required national laws until mid-1993. In Spain, for example, the «Directiva 89/106 CEE del Consejo de las Comunidades Europeas sobre los productos de la construcción» /3/ was passed as the adoption instrument on December 29, 1992 and published in the «Boletin Oficial del Estado» on February 9, 1993.

According to the «Building Products Directive», a European Technical Approval is to be applied mainly to such building products for which a relevant harmonized standard does not yet exist or will not be available in the foreseeable future. Since fasteners such as the undercut panel anchor come within the scope of the «Building Products Directive» and are not and will not be regulated by a product standard in any EEC member state in the future, it could be envisaged that this fastener or the complete facade system including fastener is regulated in the future by a European Technical Approval for the European internal market.

This technical approval is not at all a new instrument introduced by the «Building Products Directive» of the European Community, but is already an integral part of the existing national legislation in a number of member states. Such approvals are partly required for certain fields of application in existing statutory regulations such as building acts or standards for use. To obtain this approval, in Germany, for example, the applicant (supplier of the product) has to submit the required appraisal documents, comprising a test report and, if required, an advisory opinion to the Deutsches Institut für Bautechnik (DIBt) in Berlin. This institute then compares the results of the appraisal documents with existing requirements and, if assessed positively, issues a certificate of approval which can then be regarded as a confirmation that certain requirements have been met and which contains information on the allowed conditions of use for the product user. This certificate is issued for a limited period of validity and can be renewed upon its expiration, with an adaptation to more recent findings being able to be made.

In the Federal Republic of Germany, at present there exists a certificate of approval /4/ for the «Vilbofa» facade system of Villeroy & Boch in which the undercut panel anchor FZP 11 x 7 M6 K is

included as the fastener. The appraisal documents for consideration of the approval have been prepared for a similar facade system of Marazzi. The issuance of the approval is expected in 1994.

4. References

/1/ Test report of FMPA Baden-Wuerttemberg dated May 16, 1991 on the loadbearing behavior of the Vilbofa facade system of Villeroy & Boch with ceramic panels fastened on the rear side using fischer-ZYKON panel anchors FZP 11 x 7 M6 K (published in German)

/2/ EEC Directive 89/106 dated December 21, 1989 - Building Products Directive - (published in English)

/3/ Directiva 89/106 del Consejo de las Comunidades Europeas sobre los productos de la construcción (published in Spanish)

/4/ Institut für Bautechnik, Berlin, Approval Certificate No. Z-33.1-23 dated July 8, 1992, for Vilbofa facade fastened invisibly with fischer-ZYKON panel anchors FZP 11 x 7 M6 K (published in German)

FIGURE 1

Principle of a ventilated exterior wall cladding

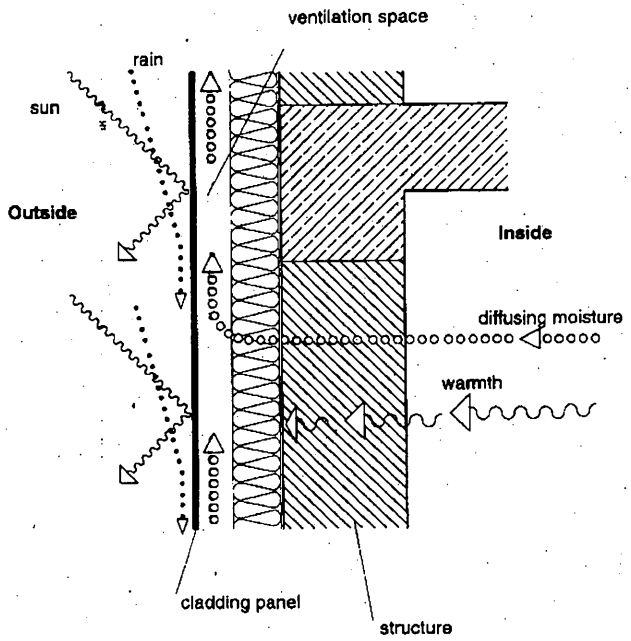


FIGURE 2

Visible fastening of ceramic cladding panels with holding clamps

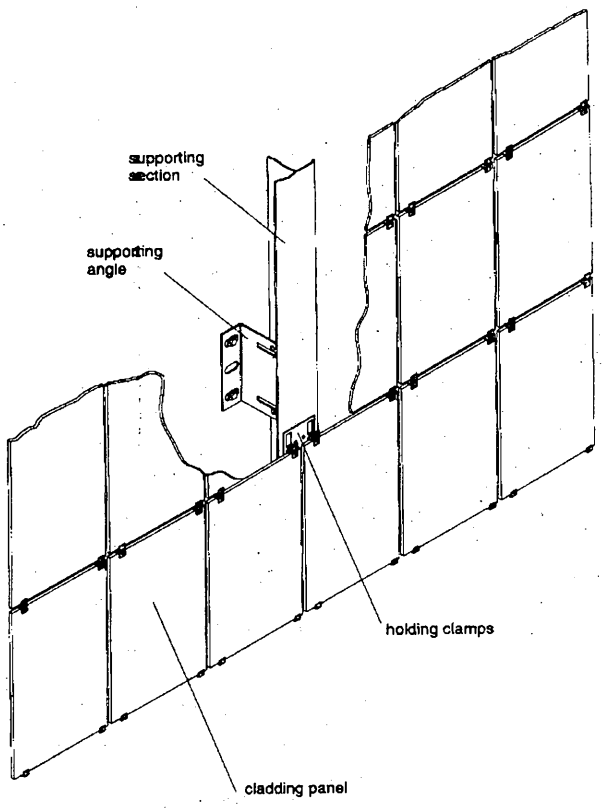


FIGURE 3

Example for the geometry
for an undercut panel anchor
in the cladding panel

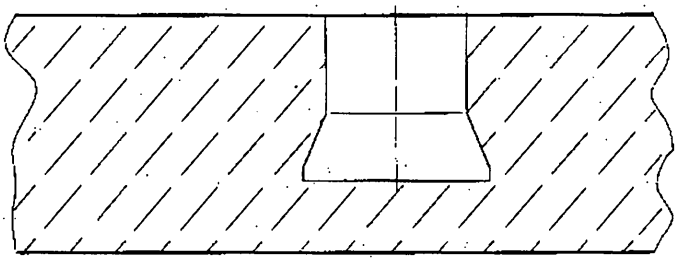


FIGURE 4

Example for an undercut panel anchor
(FZP 11x7 M6 K)

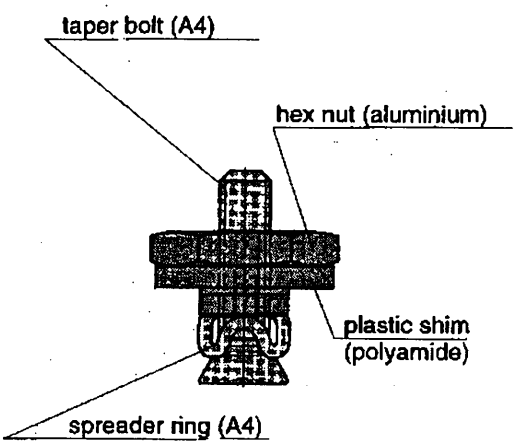


FIGURE 5

Fastening of ceramic cladding panels with an undercut panel anchor
(FZP 11x7 M6 K)

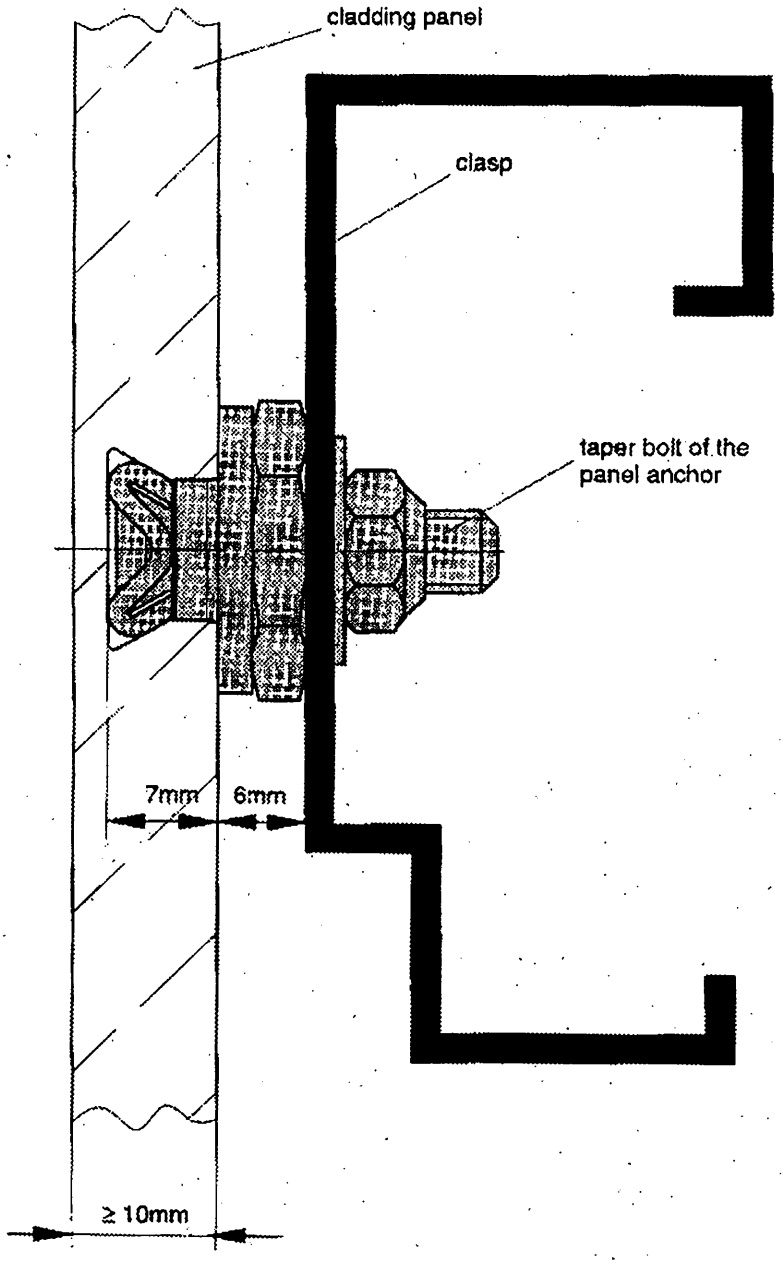


FIGURE 6

Example for a stationary drilling machine (automatic) for an undercut panel anchor

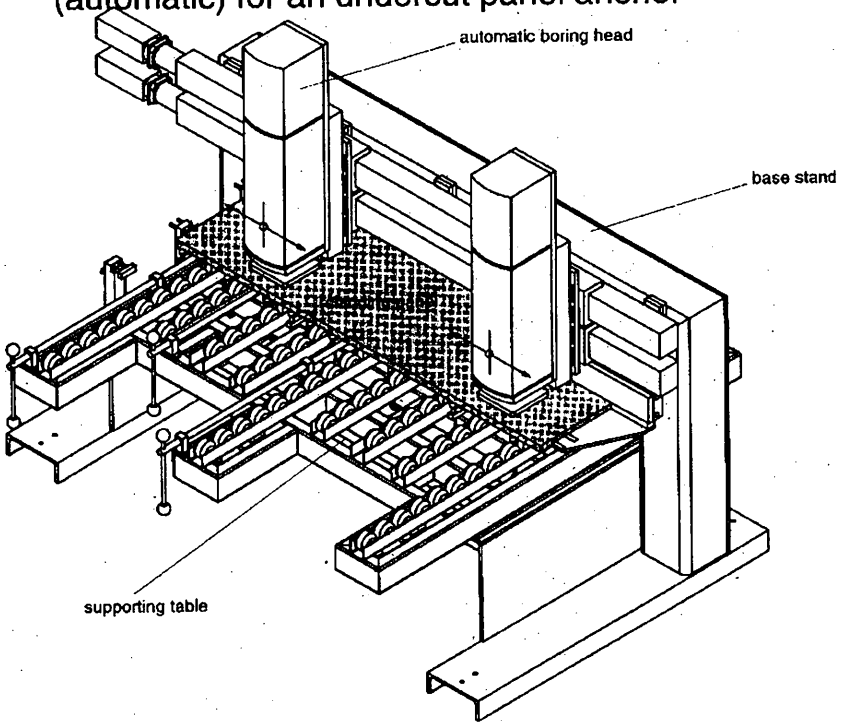


FIGURE 7

Example for a stationary drilling machine (manual) for an undercut panel anchor

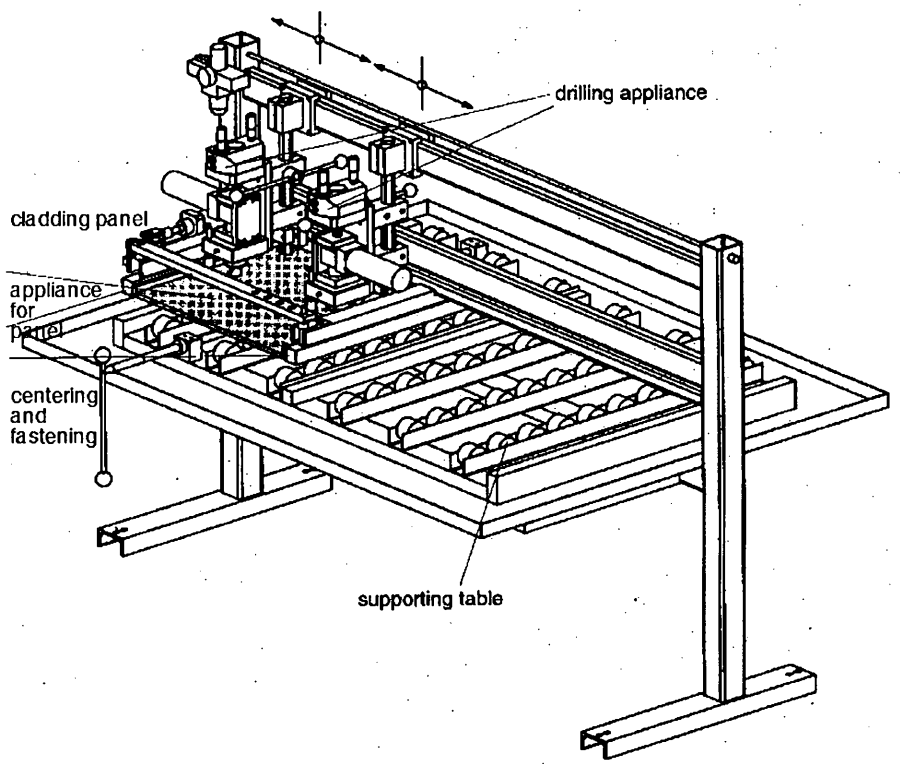


FIGURE 8

Example for a mobile drilling and setting machine for an undercut panel anchor

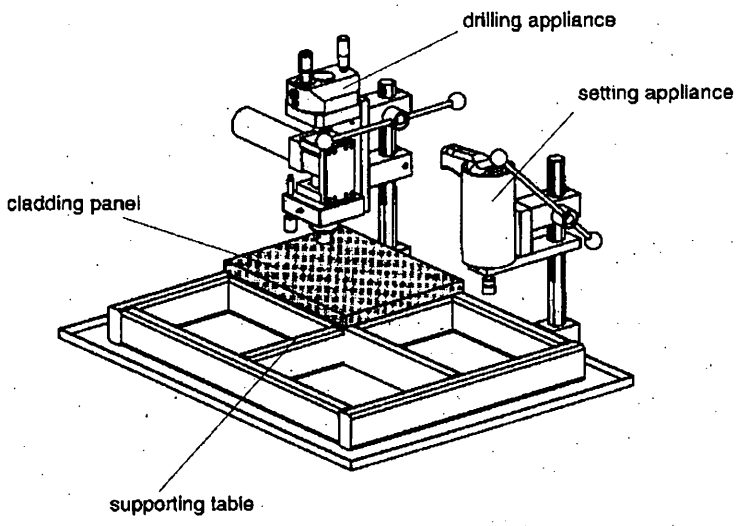
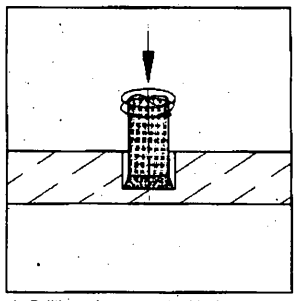
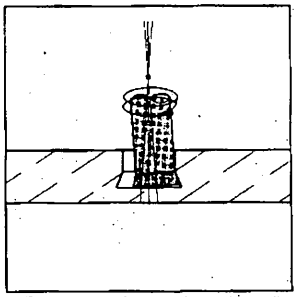


FIGURE 9

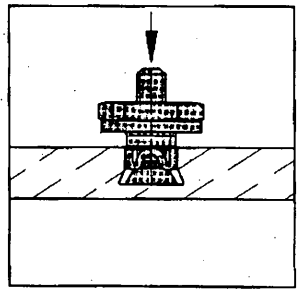
Example for a process of drilling and installation of an undercut panel anchor
(FZP 11x7 M6 K)



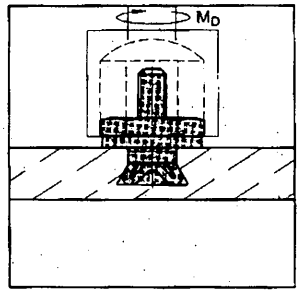
1. Drilling of a cylindrical hole with a diamond-charged undercut panel drill



2. Production of the undercut by radial swivelling movement with an undercut panel drill



3. Insertion of the undercut panel anchor into the drill hole



4. Expansion of the undercut panel anchor by applying a torque to the hex nut

FIGURE 10

Constructive formation for a four–point bearing of the cladding panels without stess

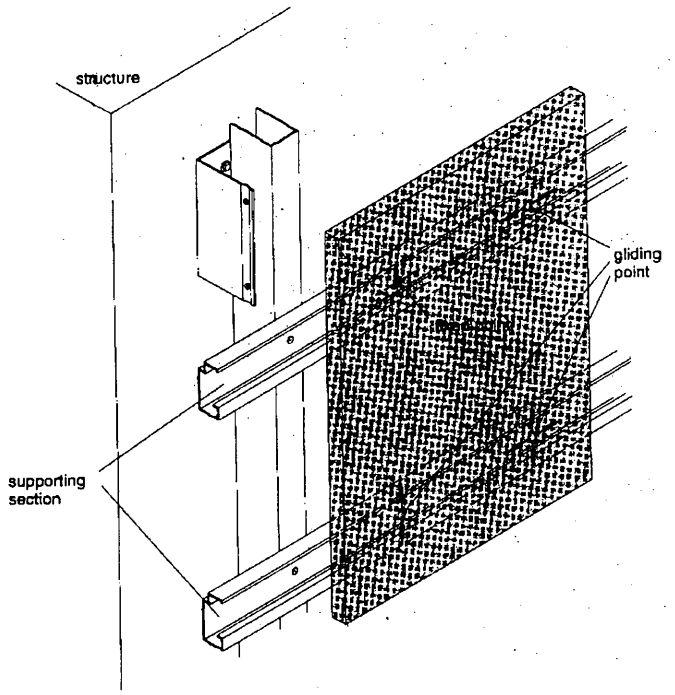


FIGURE 11

Possibilities for adjustment of irregularities and manufacturing tolerances