been rare to find a company providing a performance bond to an employer seeking comparable indemnity from its sub-contractors. Through the unwillingness or unappreciated need to redress a contractor's exposed position, a contractor has had to hear the burden of sub-contractor failures, the bulk of the statistically high failure rate reported for the construction industry. This statistical fact must inevitably colour the thinking of those engaged in bonding contractors. It can readily be seen that a surety has been concerned not only with the financial health of a contractor to complete the work, but the contractor's ability to absorb, without disastrous effect, the failure of a subsidiary contractor or supplier engaged on a contract and the company's technical and managerial expertise.

In summary, a performance bond serves two purposes. At its face value it indemnifies the employer against financial loss, subject to an agreed limit, should the contractor fail to complete the contractual works. The issuance of a performance bond by a surety affords the employer a second opinion of the validity of the bid or tender. In so doing the surety more or less says that the obligations facing the contractor are known, manageable and complementary to the contract about to be undertaken. The fact that the surety will take security in one form or another from the contractor is further assurance that the employer and the contractor are wise in their declared intention to enter into formal contract with each other. The employer can take comfort in the knowledge that the surety will monitor the affairs of the contractor if only to protect himself and so offer a continuing stewardship acting to the mutual advantage of the employer, the contractor and the surety.

Sources:

General Surety & Guarantee Co. Ltd., Manchester (who publish a descriptive booklet "Bonds & Guarantees").
Sun Alliance & London Group, London.
Federated Employers Assurance Co., Ltd.
Tate Emes & Co. Ltd., brokers, London.

Slip-Forming can save time and costs

by Professor W. Heynisch

Techniques of slip-forming concrete with moving shuttering have nowhere received more attention than in the German Democratic Republic. The solutions evolved in the construction of many notable buildings are here discussed by the President of the Academy of Building of the G.D.R., Professor W. Heynisch, who has acted as a consultant in the design and construction of a number of slip-formed buildings.

This article is reproduced by the kind permission of the Editor of Batiment International/Building Research and Practice, *the Journal of the CIB. Unfortunately we have been unable to reproduce some of the fine photographs which illustrated Professor Heynisch's original paper.*

The slip-forming method of concreting is quite common for erecting tall cast-in-situ industrial-type structures, for example silos, cooling towers, chimney stacks, TV relay stations and so on. The many types and shapes of structures constructed by this method prove its flexibility. It also has the essential merit that, in addition to the comparatively low basic investment required, the speed of erection and the resulting economies increase with the height of the structure.

In order to apply these advantages to as many other types of buildings as possible and at the same time to improve on existing techniques, extensive development work has been carried out in the GDR. Techniques were evolved for slip-forming conical chimneys up to 300 metres high as well as hyperboloidical shells for cooling towers of approximately 80 metres diameter and 115 metres height. Considerable experience with structures of this type eventually sparked off research into the application of the slip-forming method to housing and related construction. The intention was to open up new possibilities of combining high-rise architecture in urban planning with the advantages of industrialised methods and rapid construction.

By employing the slip-forming method quite exciting focal points have been achieved within towns for residential buildings, for hotels, for university buildings, for research institutions and the like.

Where walls predominate

Taking its economic threshold into consideration, slip-forming – which can be classified as an industrialised method of construction – can effectively be used to construct tall buildings of any type that are chiefly composed of walls. Slip-forming has proved to be a highly efficient method of construction that allows for the comprehensive mechanisation of all operations. In addition, it may easily be combined with other industrialised methods of construction.

In the GDR a number of interesting buildings have been slip-formed during the past few years particularly in the field of non-industrial construction. This entailed adapting the technique to this type of building and thus developing its technological features. The main problems to be overcome included intricate ground plans, the construction of floors during the slip-forming process, and the simultaneous placing of the facade cladding. The buildings erected along these lines may be distinguished according to the following basic categories:

1. Cored systems, i.e. buildings with one or more slip-formed cores serving as fixed points for a framed structure. Here, the core takes all horizontal loads and may also be used for putting in a climbing crane and for effecting all vertical transport during construction of the rest of the building, as it is finished before assembly of the framing commences.
2. Fully slip-formed systems, i.e. buildings in which all load-bearing external and internal walls are slip-formed and the floors either incorporated simultaneously or afterwards. With these systems it is also possible to open up the walls to such an extent that they, in effect, become frames.

Integrated construction

In the first case the slip-forming process is subordinate to the construction technique specified for the rest of the building and only contributes indirectly to the total job efficiency.

In the second case the technique is applied to the whole of the building. Here, it is of utmost importance that an optimum integrated and highly mechanised method of construction be conceived that will comprise not only slip-forming the walls but also placing the external insulation and cladding materials, constructing the floors and finishing the interior by employing prefabricated components to as large an extent as possible. The chief effect of this type of construction is a saving in total construction time over other building methods of 15 to 25 per cent.

This article is confined to fully slip-formed buildings of the non-industrial type. From the outset, three specific problems that do not occur with the industrial type buildings had to be tackled, namely:

- the incorporation of floor placement in the sequence of operations;
- the economical treatment of external walls to satisfy physical and aesthetic requirements;
- the inclusion of finishing operations, in particular of mechanical services, which gain considerably in importance in high-rise buildings.

In addition, a number of minor problems had to be solved, for instance improving the finish of the internal wall surfaces and reducing dimensional deviations by employing modern control and adjusting equipment. The procedures and methods which have been evolved may be considered in relation to the design and construction of the more notable individual buildings.

Figs. 1 and 2: *The Hotel Stadt Berlin in Alexander Platz. The tower is based on a structural core with frames either side. Floors were installed as erection proceeded.*

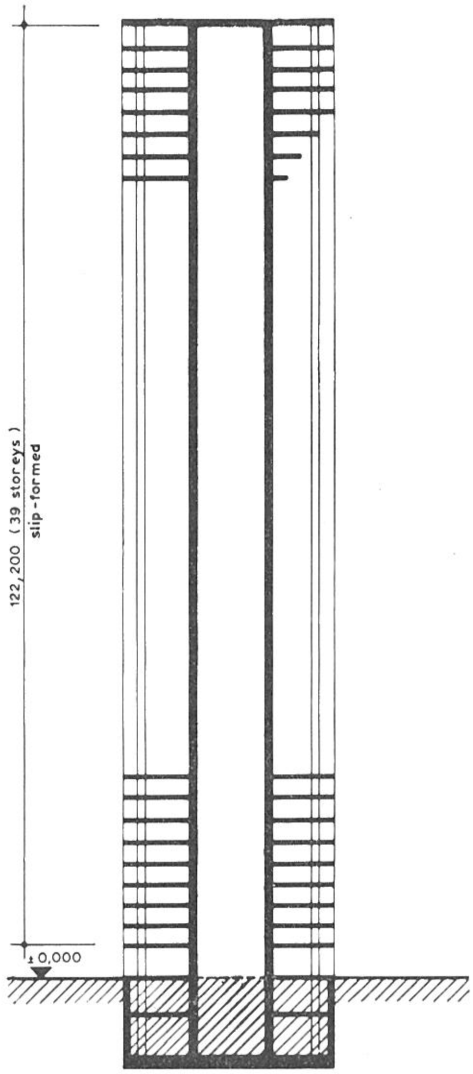

Fig. 1

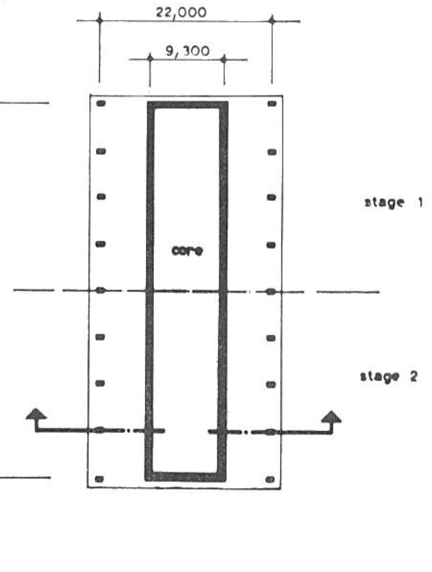

Fig. 2

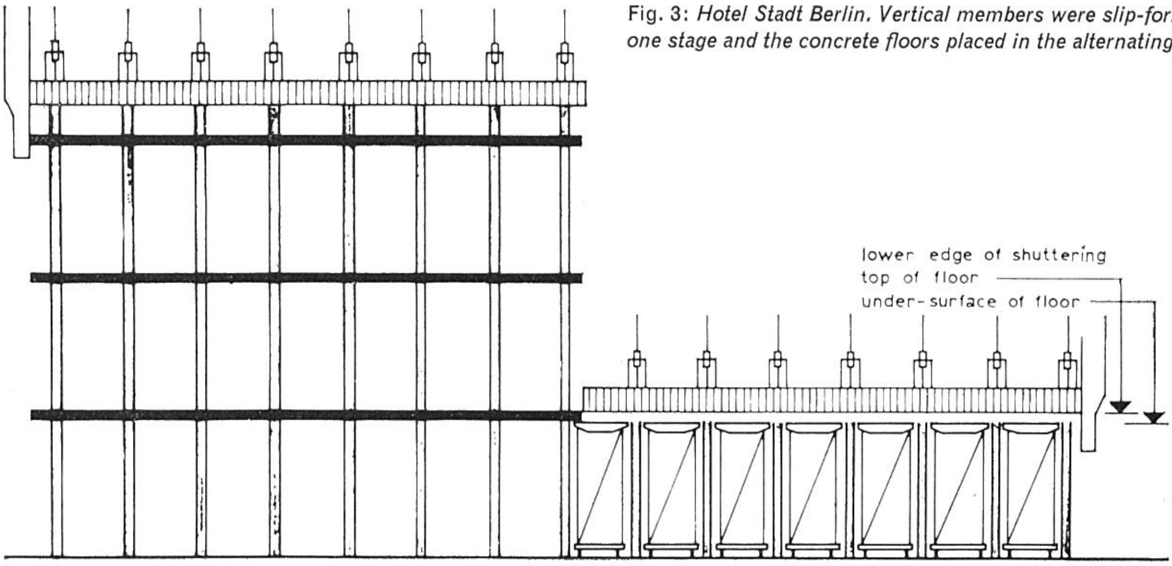

Fig. 3: *Hotel Stadt Berlin. Vertical members were slip-formed in one stage and the concrete floors placed in the alternating stage.*

Hotel "Stadt Berlin"

This building is the most prominent structure on the Alexander Platz square in the redeveloped town centre of the GDR's capital. It consists of three basic parts: the hotel proper, restaurants and garages. Most of the restaurants and garages are located in a low-rise podium at the foot of the hotel. The 4th to 39th levels in the tower above comprise 30 bedroom storeys, five storeys for mechanical services and one storey for restaurants. The tower, which measures 24m × 50m × 140m, was slip-formed in 1967.

Structurally, the tower consists of a continuous stability core taking all horizontal loads with frames on either side (figs. 1 and 2). The thickness of the longitudinal shear walls in the core varies from 800 mm to 300 mm depending on the stress, the concrete being grade B 450 and B 300.

It was possible to prove the expediency and superiority of the slip-forming technique over precast concrete

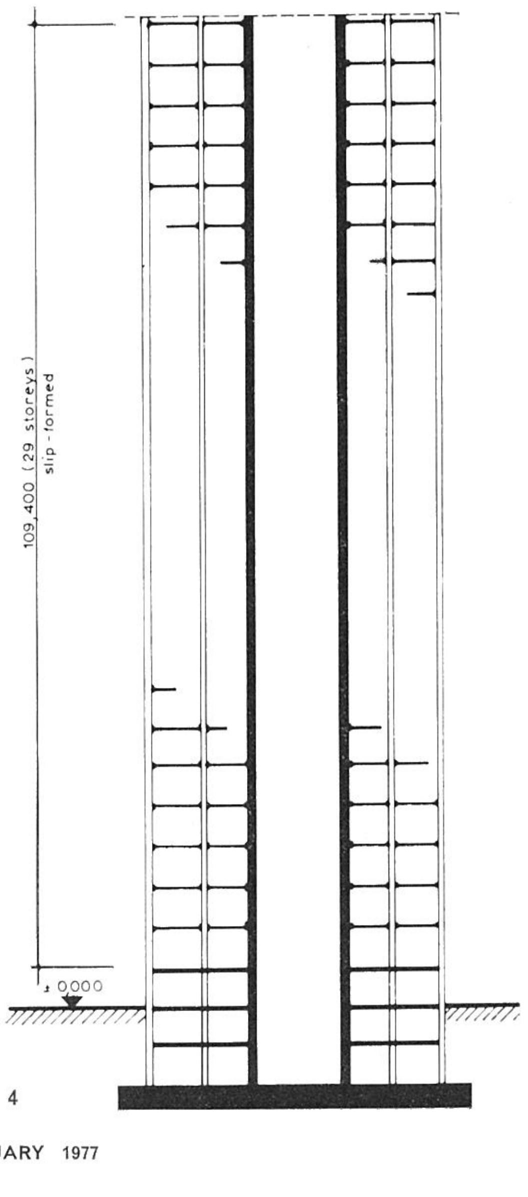

Fig. 4

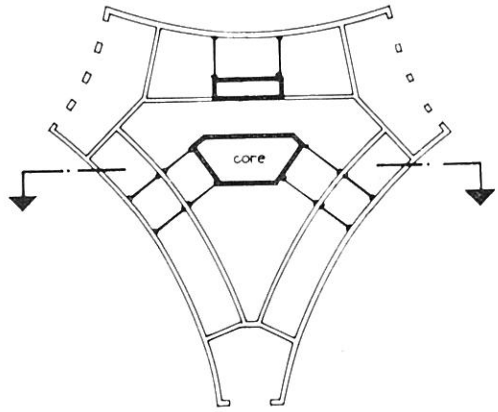

Fig. 5

Figs. 4 and 5: *The tower at Leipzig University, another building constructed with sliding shuttering, is a system of diaphragms cantilevering from a base and linked through the floors. Girders for the floors placed during slip-forming ensured stability until the floors were completed subsequently.*

frame construction for the vertical components, both frame and core. This, however, required the floors to be put in simultaneously and the use of an industrialised method as well as the instant connection of the horizontal floor diaphragms to the vertical members, storey by storey. The basic idea was to ensure stability storey-wise in such a manner that the vertical members were slip-formed in one stage while the concrete floors were placed in the other stage (fig. 3). Materials handling was done by concrete pumps and a climbing crane.

This hotel was the first non-industrial type of building in the GDR in which a framed structure was wholly slip-formed. The technique allowed for a reduction of construction time for the carcassing from 15 months to 9 months and thus for an earlier start of finishing operations.

The external cladding is composed of aluminium-framed glass curtain walling.

Tower at Karl Marx University, Leipzig

The high-rise tower is one of the new buildings for the Karl Marx University on Leipzig's central square. Its height is 120 metres. Structurally, the building constitutes a system of diaphragms cantilevering from a base plate and linked to each other through the floors (figs. 4 and 5). The thickness of the external walls is 400 and 300 mm depending on the stress, and the concrete is grade B 300 for the whole of the building.

In this rather unconventional building the slip-forming method was chosen for rapid construction of the stability core for the lift shafts as well as of the external walls. In view of the rather complicated ground plan – and the inherent danger of dimensional deviation – slip-forming was completed before work on the floors was commenced. However, six floor girders per storey were inserted during the course of slip-forming in order to ensure sufficient stability to the walls.

In spite of this additional work the walls of levels 1 to 38 were cast in 49 days. Thus it was possible to start construction of the apex as well as of the floors (haunched concrete slabs between steel beams, concreted from bottom to top using steel sheet form-work free of supports) at a very early date. This in turn, allowed finishing operations to be commenced immediately afterwards.

Concrete was placed with the help of concrete pumps; all other materials were handled by a climbing crane. This building demonstrated that substantial reductions in overall construction time can be attained by means of complete pre-planning of functional, structural, technological and finishing measures.

Tower at Friedrich Schiller University, Jena

The plans for this building were prepared along with the plans for the redevelopment of the town centre of Jena. As a result of comparisions between various plans a circular tower resting on a rectangular podium was found to be most satisfactory for work in modern open-plan offices.

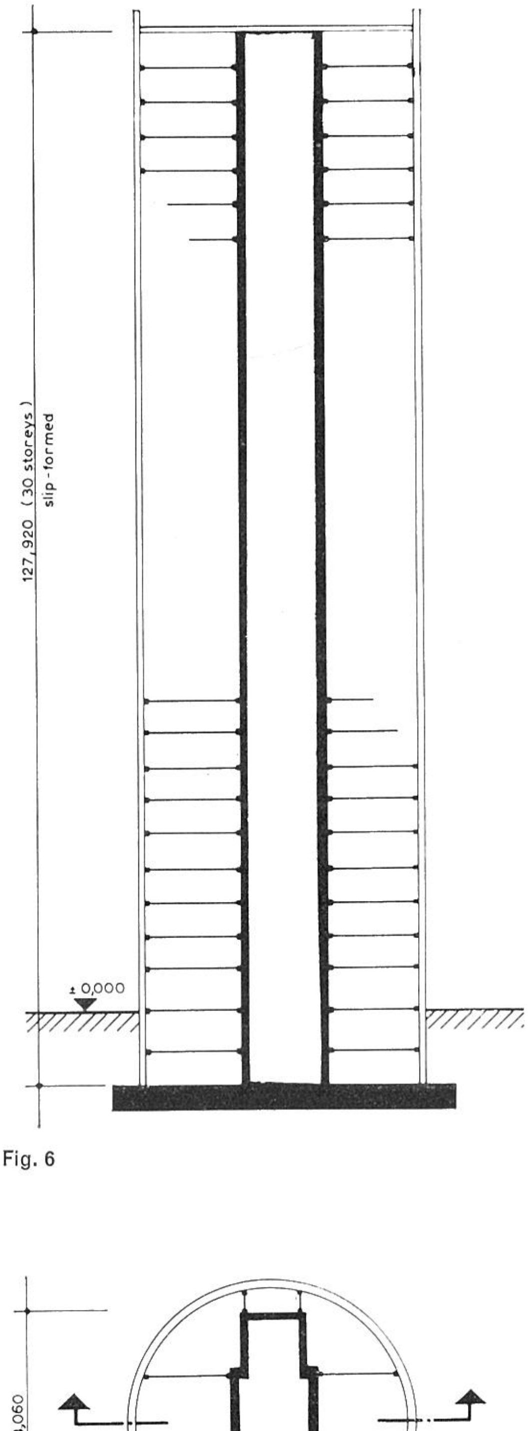

Fig. 6

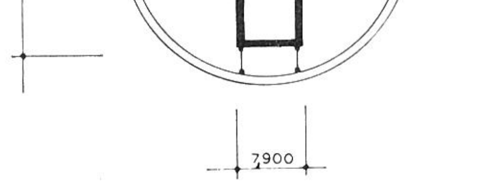

Fig. 7

Figs. 6 and 7: *An internal core was linked to the external walls of the Jena university tower building by eight steel girders per floor. A climbing crane was employed and the shuttering was braced by a steel frame.*

The 30-storeyed cylindrical tower finally decided upon measures 121.7 metres in height and 34 metres in diameter. The single-level rectangular podium around its foot provides for several social facilities.

Because of geometry and dimensions – due to the structural concept and to the time available for its construction – no alternative to slip-forming came into consideration for the construction of this new landmark in Jena. Here, however, the technique was adapted to include the construction of the floors within one complex process. Construction of the tower, including the floors, was completed within 11 months.

During construction, the tower was composed of the external cylindrical wall and the internal core, both of which were linked by eight steel girders per floor to provide the necessary stability (figs. 6 and 7).

Four of these stiffening girders (steel sheet beams of 12m length) were placed during the slip-forming process, i.e. they were placed in their final position above the working platform and then concreted into the walls by opening the interior shuttering at the points of support. This arrangement provided for sufficient stability until the floors were subsequently built in.

The floors consist of precast reinforced concrete slabs supported on steel girders with spans up to 12 metres. Connection to the external cylinder was done by grouting. Unlike the first four beams, which were cast rigidly into the walls at both ends during slip-forming, the four beams put in afterwards were provided with sliding bearings by means of slide plates within the concrete walls. Thus it was not necessary to provide for a special fire-proof encasement of these beams.

In the final structure the core and the external cylinder are considered to act in unison. The walls are made of grade B 300 concrete, the thickness of the cylinder wall being 500 mm up to the 12th storey and 400 mm above. Concrete was again conveyed by pumps and a climbing crane handled the reinforcement as well as all other components. 80 jacks of 8 Mp capacity each were employed to move the shuttering which was braced by a steel frame. The final amount of vertical deviation was found to be $\pm$ 43 mm. The facade is two-leafed, the inner leaf comprising the slip-formed wall, the thermal insulation and the standard timber-framed windows. The outer leaf consists of steel, aluminium and glass panels supported by steel sections at a distance of 300 mm from the slip-formed wall (fig. 8).

Apartment tower block at Leipzig

In order to increase the applicability and the economy of the slip-forming method it was necessary to devise means of including the final elevational treatment in the slip-forming process. While this was not attempted in the examples discussed above, the author had suggested carrying out relevant experiments in the construction of a cooling tower to combine both operations into one. The respective tests proved the feasibility of combining the placement of the external cladding units and the slip-forming of the walls into one integrated process.

On the initiative of a contracting company this combined technique was subsequently applied for the first time in the GDR in the construction of a residential tower block of 98 metres height in the immediate vicinity of the Leipzig central railway terminal. All the external cladding was installed during the slip-forming process which proves that it is possible to construct and finish the entire external wall within one single operation,

Fig. 8: *Spaced 500 mm from the slip-formed inner walls of the Jena university tower, the façade of glass and metal panels is supported on steel sections.*

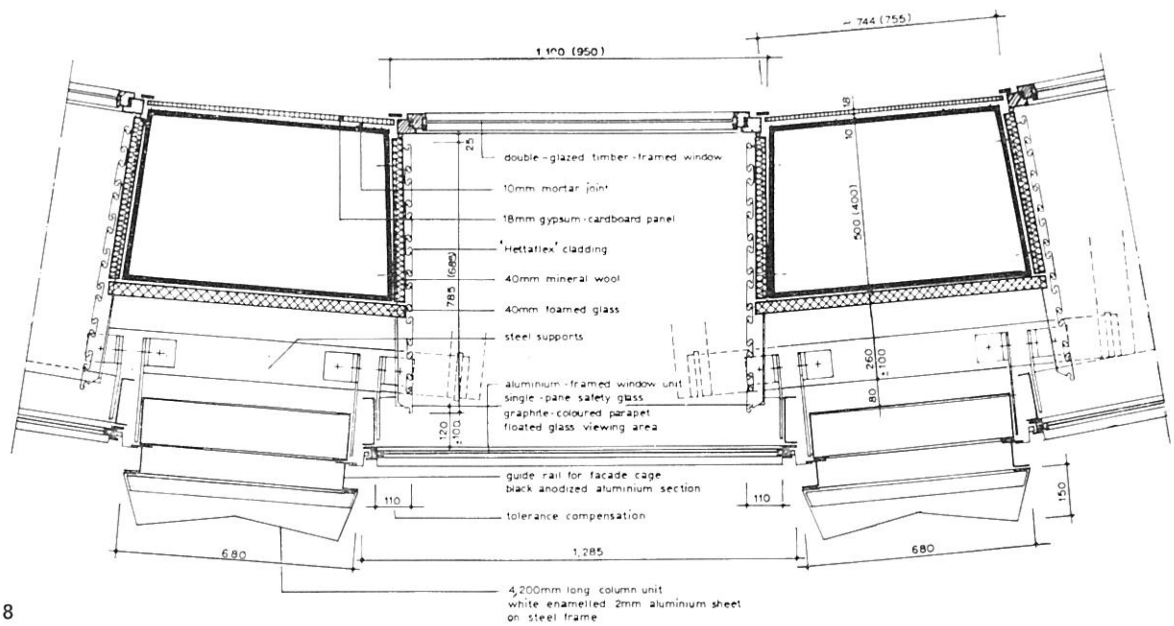

Fig. 8

provided the cladding units are designed accordingly. In this case, coloured precast slabs and a layer of thermal insulation joined by stainless steel ties were specified to provide the external finish to the slip-formed concrete wall (fig. 9). This type of combined construction requires particularly high quality workmanship, in particular the employment of crews of experienced workmen. In spite of the intricate plan of the octagonal structure and a slip-forming speed of 1.5 to 1.8 metres per shift, the finish achieved was good. The important point is that a precast concrete facade incorporated in the slip-forming process involves less expense than a curtain wall added afterwards. Architects, engineers and building workers have thus succeeded in opening up new possibilities of streamlining the slip-forming method in housing and related construction by combining the elevational treatment with the structural wall construction.

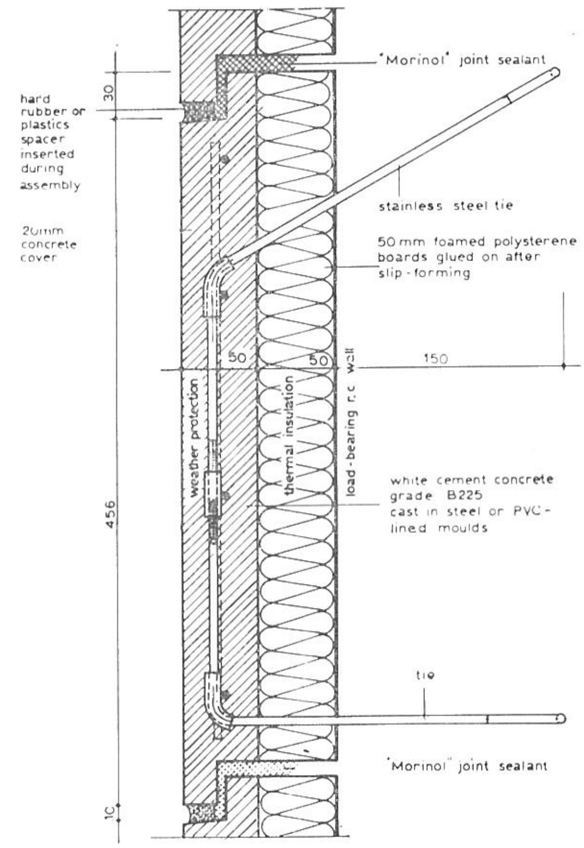

Fig. 9: *Illustration of the method of installing external cladding during the slip-forming process.*

The lessons of experience

The following conclusions may be drawn from the high level of development of slip-forming techniques for industrial, social and residential buildings in the German Democratic Republic, as well as from experience gained with the method in other countries:

1. Close and systematic co-operation between research workers and practitioners is essential in all phases of the development of a new technique, from the planning stage to the final construction. This fully applies to the slip-forming techniques described above.

2. Creative, multi-disciplinary teamwork, involving architects, structural engineers, site engineers and slip-form crews, is a prerequisite to produce highly efficient projects in terms of architecture and economy.

3. A decisive criterion for the efficiency of a slip-form project is the achievement of sufficient structural stability in the course of erection. This must be done in such a way that extra costs in materials will not be incurred over the final state with the floors built in.

4. Floor construction should be planned to fit into the slipforming process, that is, it should attain the same or nearly the same speed. Slip-forming and simultaneous floor construction must conform to the demands of industrialised construction.

5. Dimensional accuracy is particularly important in respect of the subsequent installation of lifts. This requires the use of highly accurate and stable shuttering as well as control systems that will give exact readings in the minimum of time in order to guide the shuttering.

6. For developing external walls that will perform well both from the architectural and physical point of view further research will be necessary to combine into one process precast concrete slabs, coloured asbestos-cement sheets or metal plates, thermal insulation and structural concrete. In this respect special attention will have to be paid to the fixing techniques and to the design of joints. Monolithic facade design with special colouring added will also have to be further investigated.

7. Present research and experience indicate that carcassing and finishing operations have to be considered in very close inter-relationship in slip-form construction. Accordingly research and development must cover the entire construction, with special attention being devoted to the development of standard finishing units.

From consideration of experience to date, it can be said that there are still considerable savings in expense and construction time which could be achieved by means of further systematic research and development in this technology.