Nordimpianti System Srl, 66100 Chieti (CH), Italy

Precast concrete bridge elements produced with slipformer technology

For over 40 years, Nordimpianti has designed and built equipment for the production of prestressed concrete elements that does not require the use of fixed formworks. It has created strong technical and commercial links with all its clients giving Nordimpianti an excellent reputation for reliability and expert knowledge within mechanical and civil engineering. An important partner of Nordimpianti is Esse Solai company, located in Vicenza. Esse Solai is a "state of the art" company with 30 years experience of producing prestressed and non-prestressed slabs. Recently Esse Solai, as a parent company of Esse Team, has acquired two plants in Northern Italy, one in Parma and another in Udine.

The main mission of the company is to satisfy the demanding technical requirements in the structural, thermal and acoustic fields by pushing the boundaries of the most innovative and efficient production technologies.
With this company vision, Esse Solai has increased its range of production types, starting from hollow core slab production, to now well over twenty types of elements ranging between twin wall systems, ribbed retaining walls and high bearing capacity floors including the production of Top Sol® and Top Bridge® precast elements manufactured using Nordimpianti technology. Nordimpianti and Esse Solai first started working together in 2000 when Nordimpianti supplied a complete line for the production of hollow core slabs. This consisted of five steel production beds, each 150 m long, two slipformers (one for elements up to 250 mm high, the other for elements up to 500 mm high), one transversal saw, lifting beams and various other accessories.
In the subsequent years, the partnership strengthened and the two companies worked closely together to produce elements that had previously never been manufactured using slipformer technology. One project in particular saw the development of a special machine capable of producing precast elements used in the infrastructure sector with a U section and up to 1 m high. The Infrastructure sector is a significant proportion of the construction business and the technical requirements are particularly demanding. Nordimpianti responded to these challenges by its focus and development of the vibro-compaction technology

Esse Solai, based in Vicenza, is a highly respected company in Northern Italy producing both pre-stressed hollow core slabs and other precast concrete elements.

A Nordimpianti slipformer for the production of prefabricated elements for infrastructure use with U-shaped sections up to 1 meter high.

Nordimpianti's slipformer during the casting phase. Note the simultaneous use of prestressing wires and steel mesh reinforcement.

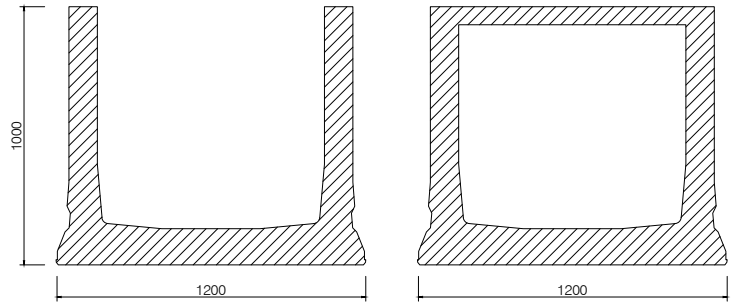

Fig. 1

(slipformer technology). This research led to the creation of a dedicated slipformer machine to produce structural elements up to 1 m high with the possibility to use three different forming inserts to meet the technical parameters of bridge elements and industrial decks capable of withstanding heavy loads.

The first forming insert from Nordimpianti, developed for Esse Solai created a ribbed slab with a U cross section that can be also is completed on site with transversal bridge slabs, usually precast slabs with exposed lattice works, and a completion concrete topping. The overall composite deck section is a boxed section with high torsional stiffness suitable for the construction of bridges and floors in which the transversal distribution of the concentrated load is of primary importance. In cases of long span elements, it is possible to install the elements close to each other obtaining a deep longitudinal shear key that reduces the transversal stresses of the top (cast in-situ) slab because of the external side profile (Fig. 1).

The biggest challenge has been the insertion of the normal reinforcement, together with prestressing wires, inside the precast element using the slipformer technology. By solving the problems around the presence of steel mesh and of the protruding stirrups from the top of the element, it has been possible to fulfil the requirements of EN 15050 (European code for bridge elements) which doesn't allow to take into account the shear friction between precast and cast in-situ concrete. The composite sections have been optimized considering the phases of life of each part improving flexibility of use and the overall economy of the projects.

To complete the box section, there is a variant whereby EPS blocks are positioned within the U or the lattice ribs thus exploiting the greater control of the materials and processes offered by factory production.

Another forming insert that can be used on the Nordimpianti slipformer allows for the production of a hollow core section with three hole voids and a low self-weight. This element has very high torsional stiffness that allows for its use in all cases where a reliable transfer load distribution is required and also where there is no structural cast in-situ topping (Fig. 2).

Use of EPS blocks positioned within the U section.

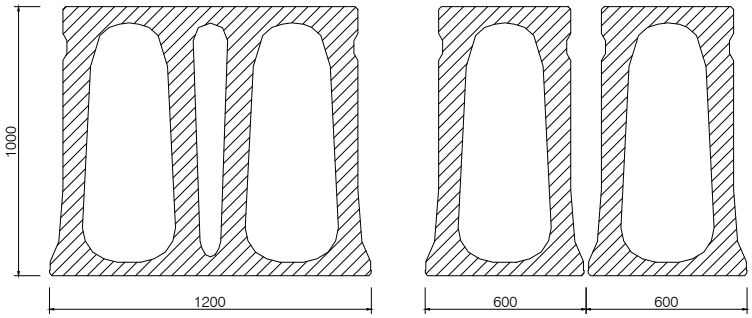

Fig. 2

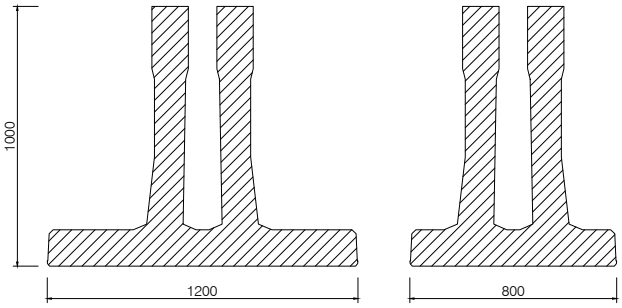

Fig. 3

The forming insert mounted on the Nordimpianti slipformer producing hollow core slabs with three holes, giving considerable weight savings.

1000 mm high lightweight hollow core slabs in the storage area.

The third forming insert from the Nordimpianti slipformer has been designed to produce inverted double T beams. This cross section allows for great flexibility. In fact it can be used for logistic and industrial building roofs using lightweight transparent panels without cast in-situ topping or for bridges using transversal filigree slabs completed on site with structural grout. This cross section has remarkable shear strength due to the two large vertical ribs that can be further increased by grouting, on site, the space between the ribs (Fig. 3).

With the last two forming inserts it is possible to easily obtain width sub dimensions. In particular it is possible to have two hollow core slabs with 600 mm widths and an inverted double T beams with an 800 mm wide bottom flange instead of 1200 mm wide. This is a big advantage because it means great flexibility in covering large decks and reducing the preparation of dedicated customized moulds on site.

As briefly mentioned before, for all configurations, the prestressing steel, welded wire reinforcement, normal rebar and all requirements

Forming insert installed on the Nordimpianti slipformer producing inverted double T floor beams: such a section allows great flexibility of use.

Box section highway underpass at the A4-A13 intersection in Padua, Italy.

have been adopted in order to fulfil the requirements of general European norms (such as En1992-1:1, EN206, etc.) and specialized ones (i.e. EN13369, EN15050, EN13224, etc.).

It must be noted also that, for all configurations, it's possible to raise the slipformer by 30 mm in order to increase the fire resistance of the precast elements allowing them to reach a fire rating of up to four hours.

The slipformer technology, used in the cases mentioned above, presents advantages for different reasons.

First of all the flexibility of use: all configurations described above can be practicably obtained by one machine, changing only the forming inserts, while with traditional formworks to reach the same level of efficiency and flexibility would require a much bigger investment.

Secondly, the quality and grade of concrete that is possible to achieve is very important. The type of concrete required for these machines is a semi-dry mix and the water/cement ratio is very low (ranging between 0.35 and 0.40): this gives the optimum benefit in terms of the final strength of concrete and for the production costs. The workability of this concrete is practically zero when using traditional methods whereas the Nordimpianti slipformer, processing relatively less concrete than formwork methods gives the optimum degree of compaction and quality.

Nordimpianti's slipformer performs uniquely in its field by subjecting the concrete to a combination of simultaneous mechanical actions, in particular compression from the shaped vibrating plates, and the longitudinal oscillation of the forming tubes and internal moulds.

The quality of the finished elements, in particular the surface finish of the exposed parts, is of a high level because of the oscillating formers. Moreover the parts that will be in contact with the cast in-situ grouts have a surface roughness that enhances the aggregate interlock and, by consequence, the reliability of the composite section behaviour.
A third consideration is that the productivity of machines that operate on casting production lines is higher than with traditional form-

Reconstruction of a bridge deck destroyed by a landslide in Serina, Italy.

works. The time for setting up the machine and the time required for concrete curing are minimised and allow for high production volumes. Below are some of the applications from Esse Solai company showing examples of the performance and flexibility of the elements produced with machines from Nordimpianti.

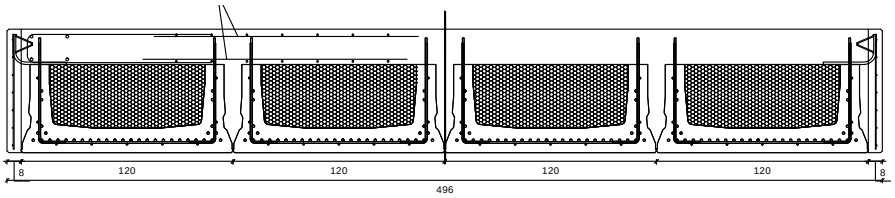

Fig. 4

Boxed sections for a highway underpass (highway of Padova, Italy):

Project surface is around 800 m², and it consists of a first category bridge with slabs positioned side by side creating a massive boxed section. The perfect alignment and the possibility to create elements with skew heads allow for the correct construction of the curved parts of the bridge. The overall depth of the deck is 900 mm (600 mm precast element and 300 mm cast in-situ structural screed) and the U shape is suitable in order to have continuity between the heads of two contiguous spans or with the retaining walls giving also improvement in supporting the soil lateral load.

Reconstruction of a bridge destroyed by a landslide (Serina town, Bergamo, Italy):

The bridge, accessible to vehicles, has a span of 16 m and the overall thickness is 850 mm (600+250 mm) and beam spaces up to 1200 mm. Existing head supports have been reused. The construction system adopted for the deck is Top Bridge. Through slipformer technology, it was possible to design, build and carry out the installation within two weeks from when the overall project was approved.

First category Bridge with 22 m span (Noceto town, Parma, Italy):

The U section construction system is suitable for first category bridge types. In particular the overall depth of the deck is 1100 mm (900+200 mm) but the required thicknesses are very small when compared with the solution of using precast I beams (Fig. 4).

High bearing capacity deck (Sant'Anna di Alfaedo town, Verona, Italy):

It happens more and more often that Architectural design becomes more demanding from the structural point of view. This application perfectly represents this point. In fact the conceptual design requires that two floors of the building are supported by columns resting on the basement instead of the normal foundation. The basement has been built with the Top Bridge system with an overall depth of 800 mm (600+200 mm) with solid zones located at column bases.

Esse Solai is at the forefront of responding to the market requirements of construction end users. This makes for a perfect fit with Nordimpianti's own constant mission to build strong relationships with its clients. Nordimpianti invests heavily in the technical professionalism of its staff who, not only have great experience of the design and optimisation of specialist machinery but also have the skill and in-depth knowledge to advise customers on all aspects of the production, transport and installation of precast elements manufactured by its equipment.

FURTHER INFORMATION

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1st Category bridge type with 22 m span in Noceto, Italy.

High bearing capacity deck (Sant'Anna di Alfaedo town, Verona) Italy.