R. De Guio, E. Bombasaro, Bedeschi SpA, Limena, Italy

SUMMARY

The actual market is evolving together with globalization and the continuous implementation of new technologies. During the last decade, extensive investments required projects to be completed in a well-defined timeframe and with respect to high standards of quality and safety; this results in the fact that the general contractor has to be oriented towards a constant increase in competition. Generally, in order to schieve targets within tight timeframes, the phases of engineering, procurement and construction need to be overlapped with a consistent increase in complexity in terms of management and coordination; this is typical of EPC projects. Indeed, major clients increase their requests for turnkey contracts in order to assign to one a single contractor the full responsibility for the whole facility. However, proper planning, effective site management and common good practices are sometimes not enough to achieve challenging targets, because of specific characteristics of the project. This report aims to analyse the technical and operative solutions considered by Bedeschi SpA to address a specific turnkey project: the engineering, procurement and construction of a 4.8 km long belt conveyor for transportation of limestone to a cement plant located in Morocco in a mountainous area near the town of Agadir, guaranteeing high standards of safety and quality during the operations. The difficulty of the local environment and the specific challenges of the project, oriented Bedeschi towards the implementation of "smart solutions" for the engineering and the construction.

ZUSAMMENFASSUNG

Der Markt von heute ist gekennzeichnet durch die Globalisierung und die ständige Einführung von neuen Technologien. In den vergangenen zehn Jahren erforderten Projekte zu ihrer Realisierung umfangreiche Investitionen innerhalb eines gut definierten Zeitrahmens unter Berücksichtigung von hohen Standards bei Qualität und Sicherheit. Diese Entwicklung hat den Generalauftragnehmer auf den Plan gerufen, der heute auf die ständig wachsende Konkurrenz reagieren muss. Um Produktionsziele in einem möglichst engen Zeitrahmen erreichen zu können, ist es im Allgemeinen notwendig, dass sich die Bearbeitungsschritte für das Engineering, die Beschaffung und die Konstruktion zeitlich überschneiden bei zunehmender Komplexität in Bezug auf Management und Koordinierung- typisch für so genannte EPC-Projekte. Tatsächlich hat heute bei Großkunden die Nachfrage nach Turnkey-Verträgen mit der Absicht zugenommen, nur noch einem einzigen Vertragspartner die volle Verantwortung für die Realisierung des Gesamtvorhabens zu übertragen. Allerdings können angesichts der spezifischen Eigenarten eines Projekts selbst die beste Planung, ein effektives Baustellenmanagement sowie die Anwendung allgemein bewährter Praktiken manchmal nicht ausreichend sein, um besonders herausfordernde Zielstellungen zu erreichen. Der nachfolgende Report versucht die technischen und praktischen Lösungen zu beleuchten, die Bedeschi SpA bei einem Turnkey-Projekt, beim Engineering, bei der Beschaffung und bei der Errichtung einer 4,8 km langen Gurtförderanlage zur Versorgung eines Zementwerks mit Kalkstein in bergigem Gelände bei gleichzeitiger Garantie hoher Betriebsstandards für Sicherheit und Qualität angewandt hat. Die besonderen Herausforderungen des Projekts mit seinen schwierigen Standortbedingungen in der Nähe der marokkanischen Stadt Agadir veranlasste Bedeschi zur Anwendung von "smarten Lösungen".

(English text supplied by the authors)

Bedeschi towards the future: The erection of a long-distance belt conveyor in inaccessible areas

Bedeschi auf dem Wege in die Zukunft: Die Errichtung eines Langstrecken-Gurtbandförderers in unzugänglichem Gelände

1 The project: Lafarge Holcim Maroc, long-distance belt conveyor in the rural area of Agadir

LafargeHolcim Maroc assigned to Bedeschi SpA the erection of a long-distance belt conveyor in connection with the construction of a new cement plant with a clinker capacity of 3 500 t/d in the rural area of Agadir, in the South of Morocco. The project included the design, procurement and construction to ensure the transport of crushed limestone from the quarry to the cement plant. The quarry was placed on the mountain, 470 m above and approximately 4,8 km away from the plant. The belt conveyor is the sole feeding line for the whole plant with a strategic impact on the reliability of the plant (◗ Fig. 1).

The project was awarded on a turnkey basis, and Bedeschi was appointed as the major EPC contractor to manage the whole process. The project had to be completed in only 20 months inclusive of the topographic survey, engineering design and procurement of structures and equipment, civil works and mechanical erection.

2 New technologies for the engineering phase: how to combine different requirements

"Long-distance belt conveyors are fascinating structures to design. They require attention to all details in the context of the overall project constraints. The implementation of the modular structural system into Tekla structures made it possible to optimize and adapt the structures to the new constraints as they became available", said E. Bombasaro, Project Engineer of Bedeschi SpA.

The design of the belt conveyor was developed with attention to the morphology of the area (◗ Fig. 2). For these reasons, a detailed topographic survey was conducted to allow the engineering team to identify slopes, natural deviations and possible obstacles for the construction of the conveyor.

Optimization of the engineering in order to adhere to the budget was a driving force: the importance of the achievement of a certain economy of scale degree for the structure with regular spans and trestles to allow quick and easy production was granted by identifying typical trusses and standard trestles. The 4.8 km conveyor was finally subdivided into 259 trusses of 18 and 15 m span, 21 standard access towers and a special truss girder of 30 m, designed to cross a gorge. ◗ Fig. 3 shows the steel construction of the 4,8 km long belt conveyor with a total installed drive power of 630 kW. The conveyor is designed for a transportation rate of 1 250 t/h, using a belt width of 1,0 m and a belt speed of 3,8 m/s.

On the other hand, the design was forced to be tailored as much as possible to the natural conditions of the area and to adhere to the slopes; indeed, it was considered a requirement to maintain adequate height of trestles to allow different methods of erection. This choice allowed the client and the contractor a certain freedom to evaluate the construction technique and to keep it open to various solutions for the construction, even while the single elements were under production.

Based on these premises, the project became quite complex already during the engineering phase. However, by implementing new technologies such as Tekla Structures and Trimble Connect, it was possible to increase the control of the quantities and the reliability of the production process. Tekla Structures is a BIM software for creating,

Figure 1: The long-distance belt conveyor during erection

Figure 2: View of the complicated topographic situation

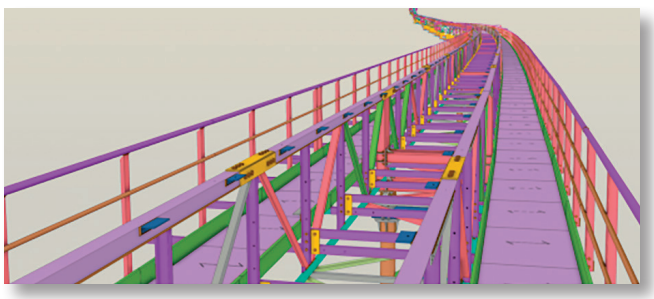

Figure 3: The conveyor's steel construction

combining, managing and sharing multi-material 3D models with valuable construction information. Trimble Connect is a collaboration tool that connects the right people to the right constructible data, at the right time. The combination of these technologies has also impressively improved the quality and the timeframe of the design. Indeed, Trimble Connect was essential in order to share models between the different agents driving the project: this allowed deep and continuous control of interfaces and a high degree of flexibility from the design desk to the site.

3 Erection of heavy trusses in inaccessible areas: a step ahead for the construction

"The erection of assembled trusses in the mountain area was an impressive challenge for our team. Our priority is the satisfaction of our client in full respect of the safety standards. Only with a smart solution such as the cableway, has it been possible to reach such tight targets", said R. De Guio, Project Manager, from the construction point of view, the critical part of the project was identified in the first 1.5 km, where the conveyor was designed to pass through the mountains, an area with difficult access, especially for the equipment (◗ Fig. 4).

In this area the execution of civil works was granted by the realization of a temporary road along the conveyor axis, with a consequent limitation of the impact on the local environment. Indeed, this track followed the natural slopes with dedicate ramps and accesses to enable crawler equipment and light vehicles to reach the foundations. This allowed the civil team to successfully complete the civil works. With reference to the mechanical and structural erection, the key consideration to reduce the time and allow fluent site operations was identified by the possibility to preassemble all trestles and trusses on the ground. The second driving factor to be considered was the assurance of adequate safety standards during the whole construction phase.

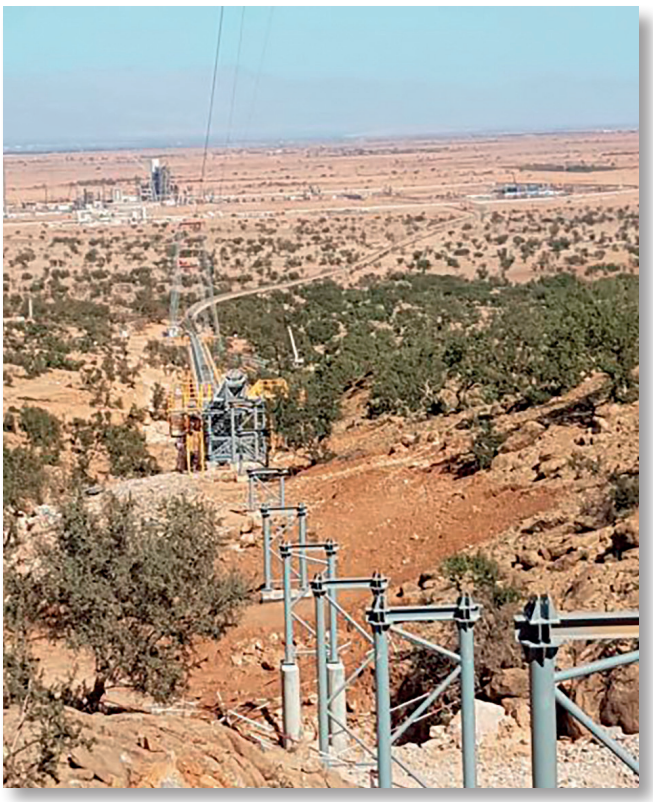

Figure 4: Difficult access for the equipment through the mountains

The common procedure to erect the conveyor by using cranes and man lifts was duly analysed as a first option; however, several site surveys failed to identify adequate spaces in which to locate the lifting equipment. Moreover, the creation of temporary carriage roads and platforms could have required a massive amount of earth works with consequently increased impact on the local environment, an extended time-frame and uncontrolled cost risks. On the other hand, the difficulty with transportation of the pre-assembled trusses in the mountain area could have consistently limited the pre-assembly degree, with heavy consequences for the construction schedule. For these reasons the common procedure was not considered as feasible for this project.

The project team also studied the use of temporary movable structures like "launch girders" to shift the trusses one by one from the top of the conveyor to the final position. These "gantry beams" should have been designed specifically to be sustained by the conveyor's trestles. The weight impact on the trestles and girder structure was estimated to be unreasonable and so this solution was abandoned.

Within these premises, the idea to use a cableway to transport the material in the mountain area was identified as a "smart system" to avoid any constraints (◗ Fig. 5). Furthermore, the Bedeschi team considered the possibility of building a tailored cableway designed exclusively to allow the erection of the trusses fully pre-assembled at ground with all accessories mounted. This possibility, could have allowed the team to complete the work within a tight schedule, avoiding problems of accesses and guaranteeing high degrees of safety during the operations. This factor was the key driver for the final choice.

4 Cableway for material handling

"It was the outstanding work of our site team to manage and coordinate the operations with this innovative solution. Many unknown variables played an important role during the erection; it was only thanks to a skilled team that we achieved such a resounding success", said G. Martari, Site Manager of Bedeschi SpA.

Once the availability of referenced suppliers of cableways was verified, this certified the reliability of the technology proposed and the feasibility of the operations with some expert in this sector, Bedeschi decided to adopt the solution

Figure 5: Cableway to transport the material in the mountain area

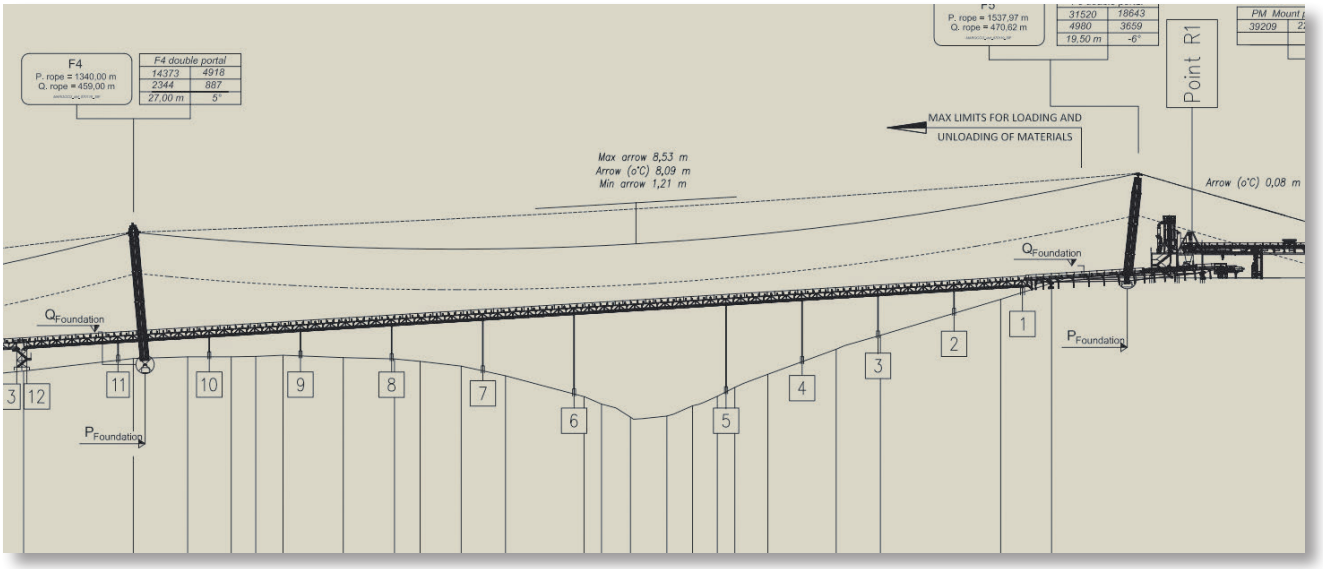

Figure 6: Schematic representation of the cableway system

to install a cableway to erect the conveyor in the mountain area (◗ Fig. 6).

The cableway system was designed and produced exclusively for Bedeschi SpA by SEIK srl, a referenced company specialized in the design, installation and commissioning of cableways for material handling. This process has taken relevant months of investigation and study, in order to adapt the design of the cableway to the specific requirements of the project. Both the Bedeschi and SEIK teams analysed together the existing mountainous area and tailored the design to allow easy operations with a high level of safety. The system was based on two running trolleys along a single rope line suspended on five towers centred above the conveyor (◗ Fig. 7). The longitudinal motion of this system was operated by an electrical motor. Each trolley was able to lift and lower by means of an independent diesel motor. The total service load was equal to approximately 6 t. Each trolley was equipped with a hook and both trolleys were designed to be placed at a distance of 12 m to safely handle the conveyor structures. The lifting system was controlled by the use of remote control and operated by a trained team.

The implementation of this solution was a technical challenge to have it in operation in due time to start erection. For the upper cableway foundation, a back-anchored solution was adopted; this required multiple 18 m long rock anchors to be driven into the ground. The valley foundation was designed as a massive concrete block to sustain the rope tensioning force. The cableway was supported by five towers with an average height of 30 m and the average distance between the conveyor and the main rope during lifting operations was granted by minimum of 8 m. The erection phase was organized in steps. At the beginning, the trusses were fully preassembled at ground including rollers, gratings and handrails for a total average weight of 5 t each: this operation took approximately three months. Then, once the cableway had been installed and certified, the trusses were lifted one by one with the cableway into the final position. This operation was carried out with a minimum number of personal assuring continuity of the operations whilst retaining a high standard of safety.

Thanks to this smart solution the site team achieved impressive productivity rates, with two teams a total of 100 m of trusses was erected in a single day. The whole conveyor in the mountain area was completed in two months. The use of the cableway led to full satisfaction of the client and the subcontractor for the high standard of safety.

Figure 7: View of the cableway, consisting of a single rope line central above the belt conveyor

5 New challenges, innovative solutions and continuous improvement

"The only way to learn new things and improve experience, is to approach challenges with innovative ideas", R. De Guio, Project Manager of Bedeschi SpA summarized the report on this unique project.

The example studied in this review, revealed how difficult constraints must be closely studied to find smart solutions and generally how challenging projects need to be taken on properly by the contractors in order to succeed.

In this case, the Bedeschi team evaluated carefully the constraints of the project, considered all the possible options and finally decided to proceed with an innovative solution to overcome the difficulties. The main drivers for the team in all evaluations and choices was compliance with the client's expectations by assuring a high degree of quality and safety; this was essential to achieve the final success of the project. ◂