CE **certification[1] requires a technical file. Jurisprudence requires the calculation notes of the machine[2]. Still need to have the right data to perform these calculations.**

Technical study and calculation
of a conveyor for *CE* certification

For relevant calculations, calculating conveyors requires a large amount of data. However, this requires a thorough knowledge of the domain and a lot of time, as well as the exploitation of the data and the execution of the calculations, with the optimizations, the iterations.

Without relevant calculation no CE certification, no mechanical results guaranteed!

THE CONVEYOR, A VITAL EQUIPMENT...

Conveyor handling involves several statuses in production equipment:

- It is a major means of production, but without added value; for example for handling in a port.
- It is intermediate linking equipment that does not produce added value but is necessary for production machinery (Fig.1).
- It is a conveyor bringing a transformation to the product handled (added value), for example, the conveyor "ripener" of ore cakes on which the product is transformed by hexo-thermie (advance of very slow band). This case is rare.

Whatever the status of the conveyor, it's out of service reveals its importance in a production. This "revealed" importance warrants our full attention.

...WHO CAN COST YOU EXPENSIVE

A non-optimized conveyor can be a significant cost source for your industry. According to the head of the maintenance department of a cement plant, the cost of maintenance over 20 years of the conveyors of the factory far exceeded that of kiln; equipment yet major for this industry.
In addition to maintenance costs, it is necessary to consider the cost of production shutdowns caused by conveyor failures throughout the process.. In some industries, these production stop costs are major as I have seen with amounts up to 50.000 €/h.

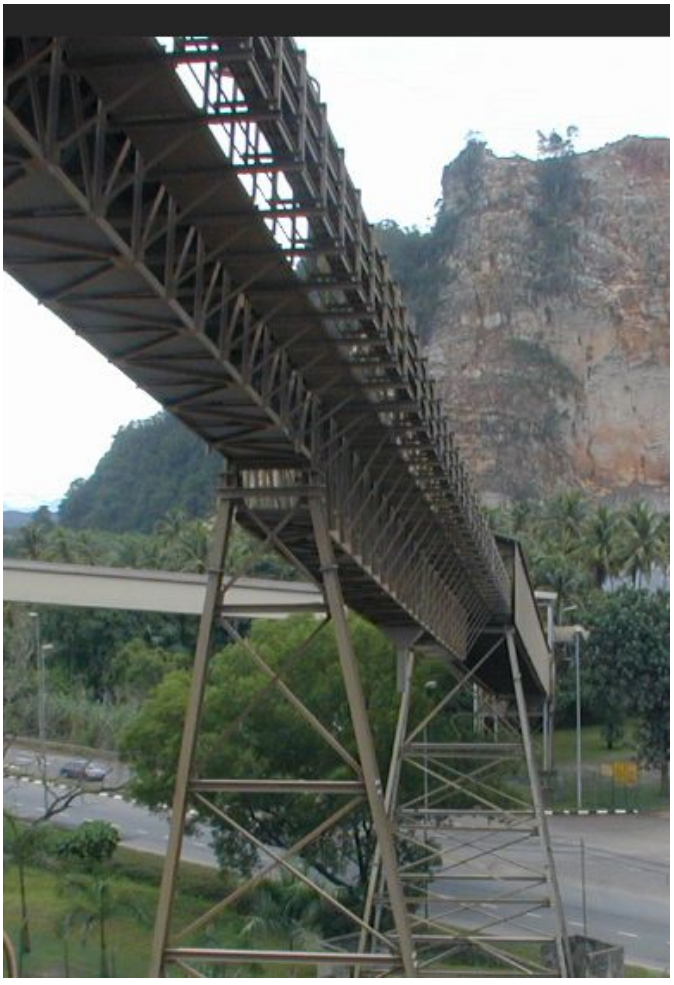

Figure 1 : conveyor of connection quarry to plant

In addition, there are maintenance and operating costs, such as cleaning, or replacing components and

energy. Over the year the addition of these costs becomes significant.

...AND THAT ARE NOT DANGER

Here, it is a question of considering the consequences of accident.

The INRS Institute[3.1], in its documentation EPICEA[3.2] reports 125 accident records in France, involving a conveyor, between 1990 and 2006, including 53 deaths. In the same vein, Jason David Lucas's Mine Safety & Health Administration (USA) survey reported 50 conveyor-related deaths between 1995 and 2007; another source of Mr. Lucas indicates 459 accidents between 1996 and 2000 in the mines. The study estimated the cost at $ 1.9 million per accident on average. The last fatal accident in France, of which I was informed, dates from November 8, 2018 (the fatal accident point it's a return idler.

These costs of maintenance, loss of production and, potentially, accidents can and must be reduced; and it's **the technical study of the conveyors, supported by the calculation**, which will allow it.

THE LACK CALCULATION IT'S RISKED

Beyond the various and important benefits that can result from calculations, they will be required in case of expertise and, if executed, they will bring credibility to the *CE* certification.

European regulatory framework

If Annex VII of Directive 2006/42/CE does not require the calculation notes to be included in the technical file, these are essential, to prove the good design of the machine so as not to expose itself to a "*doubt about compliance*".

Take the example of a fatal accident on a component whose fixed protector had been dismantled, which initially rejected the manufacturer of any responsibility. However, the Expert has demonstrated that this component (a snub pulley) has no justification for the proper operation of the conveyor. For this, the Expert has filed in court the calculation notes "with" and "without" snub pulley to motivate his statements.

Regulatory framework

In the study phase, it is important to define several versions (as shown in Figure 2) so that only the most efficient in terms of sustainability, energy saving and safety are retained. This must pass through the calculation, the notes of which will be attached to the technical file to attest to having conducted the technical study in accordance with EN ISO 12100.

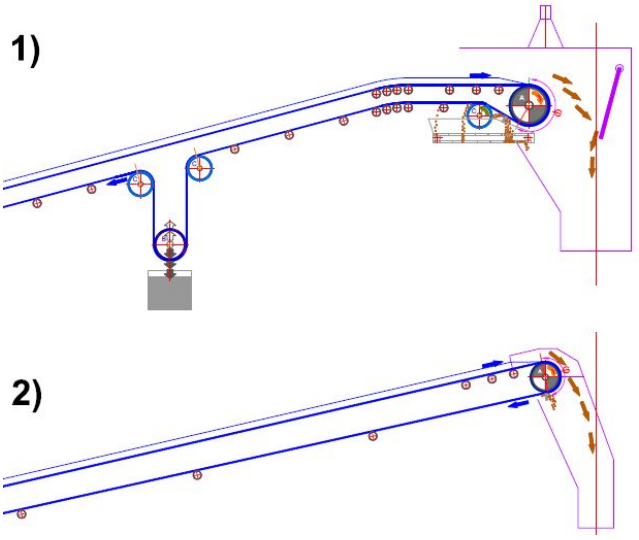

Figure 2: design : 1 = usual, 2 = optimized

The same applies to a rehabilitation or upgrade of a conveyor that requires an update of the technical file, which leads to the regulatory texts above.

Safety at the heart of regulation

In compliance with the Directive, Articles 173, 174 and EN ISO 12100, articles 4 and 6, it's important to carry out simultaneously the technical study and the safety study, with the 1st obligation to eliminate any dangerous point, unjustified for the proper functioning of the machine.

Only the calculation can arbitrate on the technical justification of a dangerous component.

As an example, consider a 425m center-to-center conveyor (Fig. 3) that had 9 pulleys in the original design. After calculation, it appeared that the smooth operation required no more than 2. It should be noted that in addition to bringing its operator into compliance with the regulations, **this operation solved many belt deportment disorders** that had motivated this operation.

Resolution of breakages and recurring wear

the use shows that in case of breakage or wear of a component, the maintenance service replaces it, often, identically and sometimes by oversizing it empirically. Thus, when these incidents originate in a defect of original design, the problem is repeated. This should be avoided by calculation.

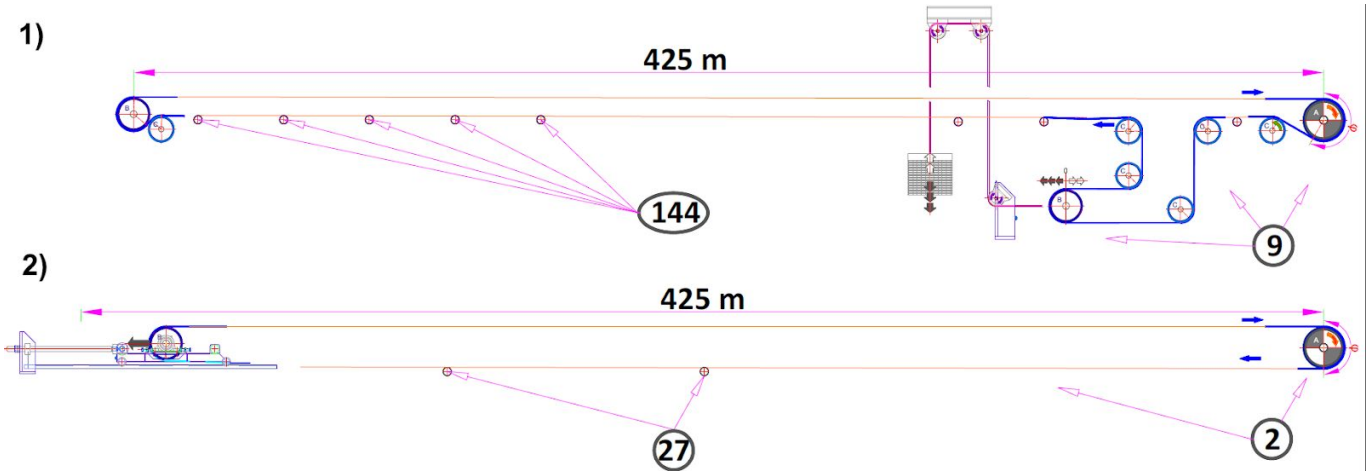

Figure 3: Conveyor length 425m, design: 1 = usual, 2 = optimized

Take the example of a new conveyor on which has been observe of lateral creep of belt and several sliding of pulleys in their bearings, without a causality analysis / consequence between the two disorders. After several repositioning of the pulleys and some settings of rollers, the disorders persist. the requested Expert recalculates the conveyor and shows that several weak points affect the pulleys; in summary, the shaft and the ferrule of the implicated pulleys flex (banana profile) which is the major cause of the belt creeps. Without proper calculation, it would have been difficult to resolve the disorders quickly. QED.

Take this other example presented in Figure 4. The life of extractor conveyor belt under a wagon emptying did not exceed 3 months. Calculations have identified a localized over-stretching of belt due to reduced width under load. These calculations made it possible to modify the equipment (hopper, spacing of underload idlers and under the emptying-door, section of this door, etc.) in order to better distribute and reduce the forces in the same belt.

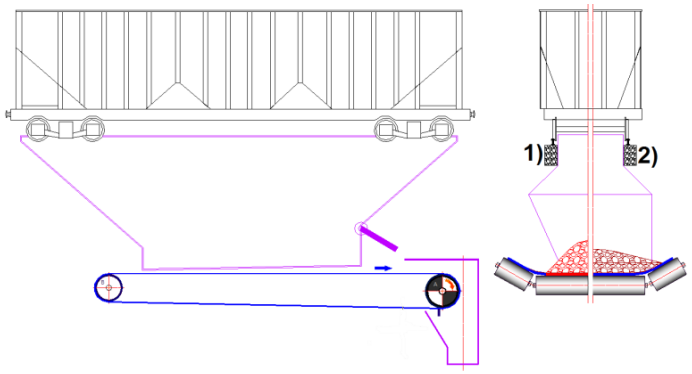

Figure 4: Product is: 1=concentrated; in 2=spread

DIFFICULTIES OF CALCULATION

Conveyors involve a large number of parameters to be considered. This approach shows that it is not about banal machines, accessible to all.

This difference in perception is, in my experience, one of the causes of the many difficulties that affect the world of conveyors, often due to a weakness in calculations, both in terms of their design and resolution of incidents. They are based on habit and use, which is contrary to a methodical approach by calculation.

NO CALCULATION WITHOUT JUST DATA

The first point affecting the quality of the calculations comes logically from the data that are proposed as input in the calculation software. eg, many computation requests, which were presented to me, reported a snub pulley without indicating the wrapping arc of the belt. Nevertheless, it is a crucial piece of information for the validity of the calculation.

Attention, a technical study can validate a design on the functional level without guaranteeing the safety regulatory requirements; a new design with a reduced number of components compared to the 1st version must be executed.

This remark is particularly sensitive, since in case of accident, the Expert will seek to establish whether the design of the machine, questioned, was the subject of a rational study in compliance with

Directive 2006/42/CE # 173, 174 (... - remove the risk ...) and where only the calculation allows an

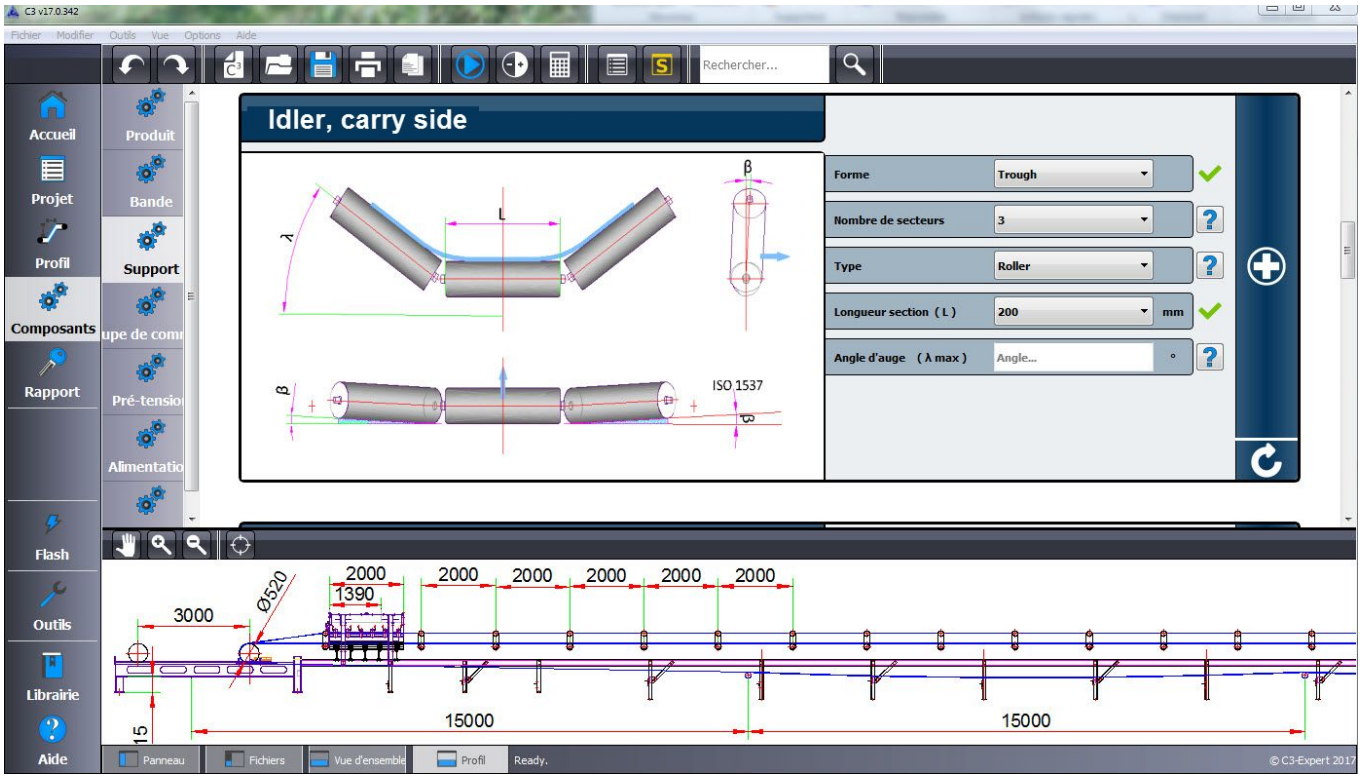

Figure 5: data screen, 1st level of input and simultaneous drawing of conveyor

objective analysis of the design. Here, it is not a question of whether the dangerous point was well or badly protected, but whether the component, seat of the accident, was technically justified.

NOTE: Often contracts with EC conformity assessment bodies are limited to ascertaining whether the dangerous points are protected or not. In this case, the delivered report presents a false guarantee, to the detriment of the obligations of the operator of the machines, since there is no study (calculation) on the utility of each component exposing to a risk.

OTHER DIFFICULTIES

An efficient calculation requires also a complete description of the components and of chronology of calculation data. Some technical criteria of the components are sometimes **not found** on the data sheets of the manufacturers.

Sometimes the description made of the conveyor is **aberrant** and cannot be exploited for calculation. As for the **chronology of the data**, it does not benefit from any standard that would facilitate relations between the applicant of a study and the operator of the calculations. These hazards are sources of errors, interpretations, loss of time and imperfect results.

No good calculation without relevant data. No relevant data without protocols to identify and collect them**.**

To hope for relevant results, we must ensure that the data are true to reality. However, the installations evolve over time and the plans, specifications and various notes transmitted are sometimes **obsoletes**.

All these problems generate an effort which is added to the technicality of the calculation. We will mention, in a non-exhaustive way, the missing measurements to be carried out on site, with all the hazards and discomforts that it supposes, which requires the exchanges of mail with repetition and time-consuming for all the stakeholders of the project.

For the anecdote, I happened to go through 280 pages of specifications to collect, here and there, all the data needed for the calculation and to see that some values were contradictory from one chapter to another of document. This imposed a clarification by the customer. All these complications may

encourage completion of the study with data "Default" with all the risks and inaccuracies that this assumes, previously stated in this article.

WHAT DATA FOR WHICH RESULTS

We have just seen that not enough data impact the quality of the calculation; conversely, too much data, unnecessarily expensive in time, impact his understanding.

The choice of the relevant data to be entered must be adapted to the needs of the various recipients of the calculation. The purchasing department will want a description of each component and their quantity when the final customer will want a detailed file of the machine. The safety manager will be interested in the dangerous points and will ensure that the optimization of safety has been well conducted (it is an obligation!). Similarly for the logistician, the commercial, etc.

These data must adapt to the context of the project. The calculation concerns a new works project, rehabilitation, the optimization of an existing machine, an increase of flow, the replacement of a belt, etc.

Some examples

- To establish the budget for a belt, it is essential to know at least the output, the installed power or the size of the conveyor.

- When calculating the load factor of the belt by a defined product, the speed of the belt, its width, its trough profile are necessary.

According to the calculation objective some targeted data are sufficient.

- When the calculation has to be complete, in the case of new works for example, the results must satisfy the needs of the entire project, define the components of the conveyor and set the limits of use for the compliance file. In this case, collecting the computation data is an important load and requires a lot of knowledge; the product libraries, components, simplify this load.

Not all information has the same importance. By focusing on the most influential data, the study can be conducted more productively. This methodology has the advantage of facilitating the mutual understanding of the parties to the project; this is reinforced by information ordered with the best logic. With its experience, C3-Expert has produced, in partnership with communicators and technicians, a methodology to address each calculation need, with relevance and efficiency.

DATA BASE

Most computation software offers libraries of components and products that simplify their input.
Other data require more work with many hazards.
Can we reduce this collection and data entry burden without error?

CAPITALIZING REPETITIVE DATA

Some general information is repetitive from one project to another, for this it is important to record them with great care since they will serve over time, which reduces the workload accordingly.

- **The recipient of calculation**

There is only one recipient or multiple recipients with different requirements identified.

- **Location of operating site**

Is the conveyor located in the CE zone or outside the CE zone, with a contract that includes or does not include the Machine Directive 2006/42/EC or with of local standards. The site standard components, expected calculations (SI, Imperial s.t., l.t.), weather, seismic or other conditions must be taken into account.

- **Les specifications**

For the sake of coherence in purchasing or component stock policies, manufacturers, manufacturers, operators promote the standardization of projects, a line of handling or for the sites of an industrial group.

- **Other informations**

Other information, which meets less frequently, can have a major impact on design. For example, the return side of belt which works in charge, which involves a specific description or the presence of unloading trolley, etc.

Despite good organization about recurring data and other imposed standards, there is still a significant burden in terms of data entry.

CALCULATE YES, BUT HOW?

Beyond the quality of the data collected and the willingness of all actors to perform calculations, a fundamental problem remains: what guidelines to give to the calculations?

The calculation softwares, as it is currently designed, merely returns the estimated operating state based

Figure 6: screen of essential results in order of importance (1)

on the choices of the operator; he remains in charge of interpreting of results to improve the design... which depends on his "talent"!

In any case, this operation which has to will lead to an optimized design, in line with the regulations mentioned above and which will present for the customer the interest of a high performance conveyor with a high level of safety, is iterative and long.

Is this not, in the end, **one of the reasons that leads to this lack of recourse to calculation and optimized design?**
Would not this be the way to go to answer the questions previously raised?

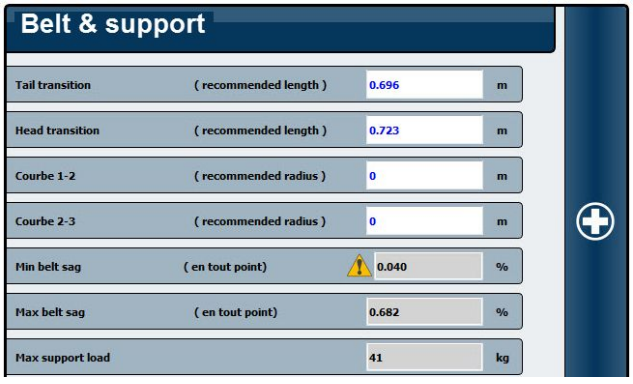

Figure 7: screen of essential results (2)

At a time when new-generation computing solutions, such as those based on artificial intelligence, are developing in all other sectors, can we not imagine tools that are better adapted to our needs, that automatically calculate designs or Optimum configurations in a given context, based on operational and economic needs, with the editing of useful documents in the format desired by each recipient of the project.

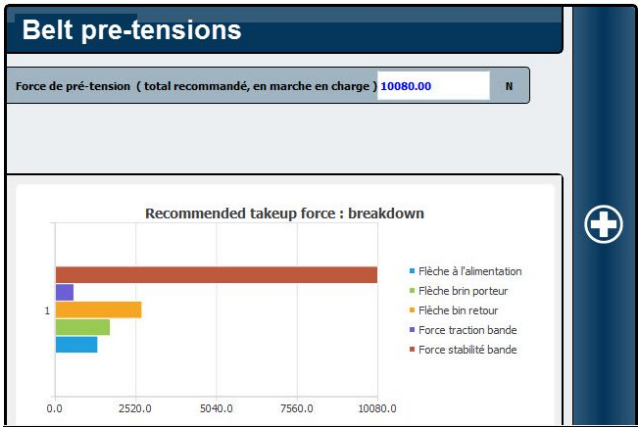

Figure 8: screen of essential results (3)

CONCLUSION

In the event of an accident, all these deficiencies can weigh heavily on the responsibility of Site Manager.

Calculating a conveyor is primarily a regulatory obligation, in my experience. This is the essential passage for a serious technical file, with a view to a sincere *CE* certification.

It must be a winning investment for the durability of the machine, its energy efficiency, its high level of reliability and safety, at the best cost.

It is the first resort in case of disorder, breakage and premature wear. What's more, from experience, many conveyors, including those who look "beautiful" at first sight, suffer disorders more or less costly and are the counterpart of an initial deficit in calculation.

To reach a high level of legitimately expected relevance, computing software with artificial intelligences is the answer to this problem, without requiring special knowledge and for a short calculation time.

1 ***CE*** : European conformity. Acronym on machines that meet the safety requirements of Directive 2006/42/CE.
2 Regulatory requirement: see "Directive 2006/42/CE - Annex VII - Technical file for machinery", which sets out the substance and form of procedure in view to *CE* certification.
3.1 INRS is the National Institute for Research and Safety in France;
3.2 EPICEA is a national and anonymous database of more than 18,000 cases of occupational accidents since 1990 for employees of the general social security.
4 AT : Accident at Work

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