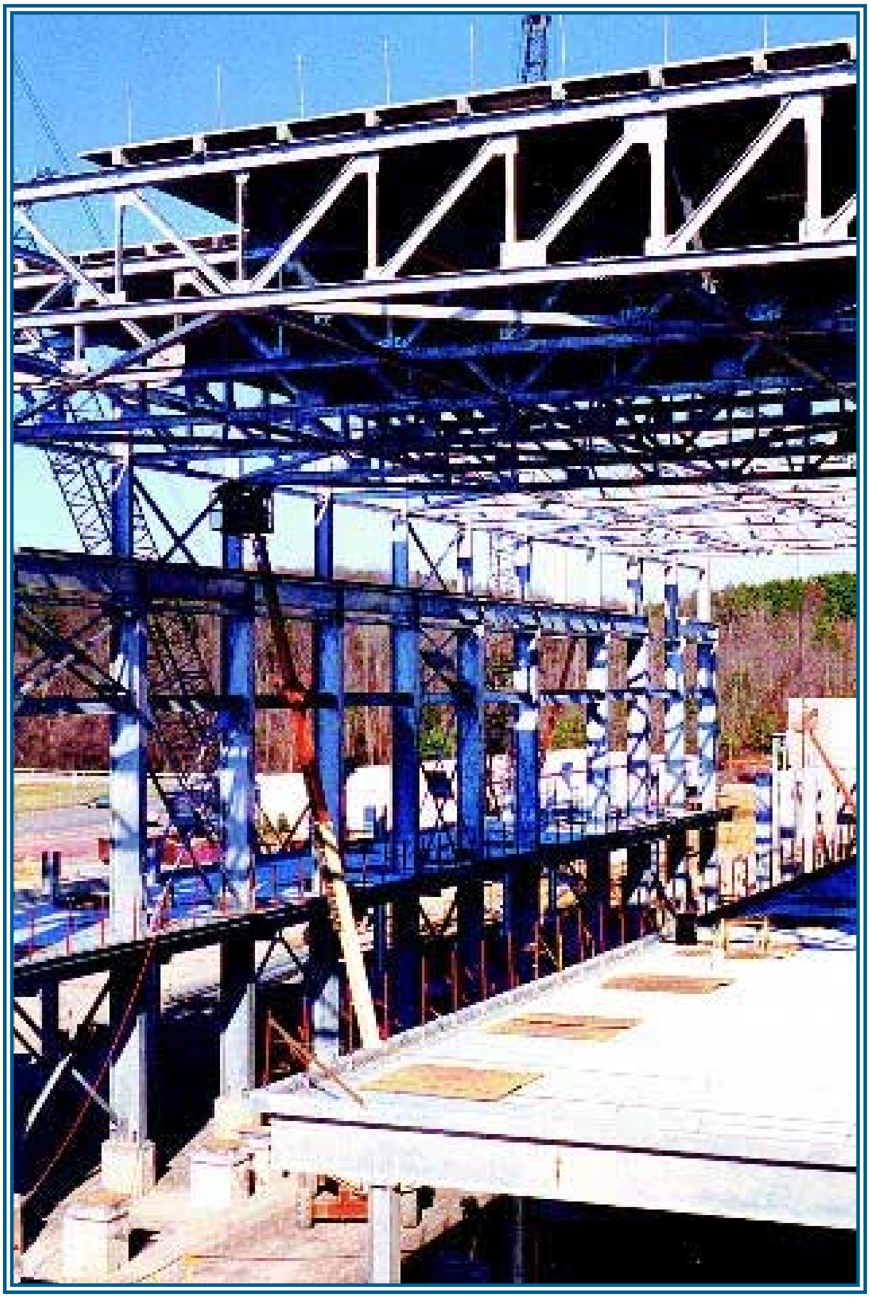

PAPER PLANT OPENS IN RECORD TIME

It only took 18 months to design and build a new 620’ x 109’ facility

By Kevin Mendenhall

TOO OFTEN, IT SEEMS THAT PARTNERING IS ONLY SOMETHING TO WRITE DOWN ON quality action statements. But at Mead Containerboard’s Stevenson, AL, site, teamwork, dedication, and cooperation among multiple companies—including previous competitors—combined to bring a greatly needed new corrugating machine online, ahead of schedule, and in record time.

Mead Containerboard’s first paper machine was designed and constructed in the early ‘70s. The S-1 paper machine produces about 415,000 tons per year (tpy). In order to bring the new S-2 Paper Machine online, a detailed “scope of work” had been generated in the early stages of the project, which helped to solidify vendor commitments. This approach promoted a sense of trust, teamwork, and dedication from the start.

Mead selected Raytheon Engineers and Constructors-Southern Division (formerly Rust Engineering), Birmingham, AL, for the design engineering, while BE & K (a Raytheon competitor), also of Birmingham, was selected for the construction. Fabricator on the job was AISC-member Qualico Steel Co.

The paper machine building is 620’ long and more than 109’ wide with two expansion joints. The building contains two 85-ton house cranes that span nearly 85’. Attached to the building are three electrical mechanical control centers (MCC), which power various areas of the S-2 project. The building contains a full-length mezzanine on one side. The S-2 Paper Machine was also designed for future expansion of the dryer section.

The S-2 Machine was positioned next to the S-1 Machine for efficiency reasons. For example, the same control operators could service both machines. Although the closeness of the buildings proved beneficial for the client, it posed several challenges for the engineer and constructor, such as avoiding large existing foundations and underground utilities as well as the actual physical tie-in to the existing structure. Furthermore, the S-1 Machine had not been designed with future expansion in mind.

One of the biggest challenges was erecting steel and setting equipment. Due to the close proximity of the existing building to the new structure, the steel could not be erected using the conventional two crane system; that is, one crane on each side of the building. Instead, all of the lifts had to be performed from one side. One of the major highlights of construction came the day when a helicopter had to be rented to set HVAC units between the two buildings. By the time the units were available to be set, the cranes could not maneuver the long reach.

The S-1 paper machine has a warehouse at the dry end of the machine. Likewise, the S-2 expansion also included a warehouse. Once the rolls are lowered though the operating floor via a lowerator, they are sent to the warehouse where they are temporarily stored until they can be loaded onto trucks or railcars for shipment.

ROOF SYSTEM

In order for the analysis and design to proceed, the type of roof system that was to be used had to be determined. There are three types of roof systems that are currently in use for paper machine buildings. The first one is the familiar purlin and metal roof system. The second uses channel slabs that span between purlins. Once the channel slabs are in place, rigid insulation and built-up roofing comprise the wearing surface. The third system incorporates precast double-tee panels that span between the roof trusses. Once the panels are in place, a topcoat-wearing surface is applied. Although any one of these systems is viable, often it is the decision of the client that determines the roof system that is utilized.

The first system did not prove beneficial to the client considering the corrosive environment of a paper machine. The S-1 Paper Machine used this system and has had a lot of maintenance issues over the years. Even though the metal roofing material can be galvanized or painted, it still does not withstand the aggressively corrosive environment. Eventually the roof will leak, possibly damaging the paper and machine below.

The second system was initially considered a viable option. The corrosiveness of metal sheeting and decking was no longer a problem. However, through research, the client and engineer determined that channel slabs still do not withstand the environment as well as the client had hoped. In fact, studies show that the concrete can spall off under deflection and actually fall into the machine causing costly repairs.

The third system, precast double-tee panels, has gained some popularity in the recent years because it seems to solve the corrosion problem as well as the concrete spalling problem. The precast double-tees rest on the top flange of the roof trusses. In this particular application, one end of the tees was fixed while the other end was allowed to float for fit-up during construction. Incidentally, since the precast panels span between trusses, all of the purlin material in the first two systems can be eliminated. This significantly decreases erection time. After the tees are in place, a nominal thickness of topping and a surface coat is added providing an excellent wearing surface.

Although the precast double-tees solved the client's maintenance problems, the engineer was charged with the task of designing roof trusses that not only had to withstand racking forces from the cranes, but the trusses also had to resist the additional weight of the precast panels. In fact, the precast panels added over 100 PSF to the load on the trusses.

PRELIMINARY DESIGN

Before the detailed analysis and design was performed, it was decided that some time should be spent researching the effects that the double-tees would have on the building frames and determine if spread footings were a viable option. Therefore, plane 2-D frames were generated for a 20' bay and 30' bay using Micas+. The first objective was to determine the maximum expected column reactions to insure that spread footings could actually be placed in the confined areas at the interface between the two machines. The second objective was to determine a reasonable, i.e. economic, truss depth. Typically, the depth of a truss should be approximately equal to one-tenth the span to achieve the most efficiency.

After making some conservative assumptions concerning the effects of the lateral forces induced by the cranes, the loads were graphically added to the model and the frame was analyzed and designed. Since the depth of the columns was pre-established based on previous experience and physical limitations, a W33 was used for the lower shaft and a W21 was used for the upper.

The column reactions verified that spread foundations could indeed be utilized. Secondly, the truss depth was set to approximately 7'-6" at one end sloping to 9'-6" at the other end. On average, this is consistent with the ten- percent rule of thumb, which would have established the depth to be approximately 8'-6". Incidentally, it was determined later that the actual truss depth should have been a little deeper in order to be the most economical.

During the preliminary design phase, the type of truss was also established. Since the stems of the precast tee would rest on its top chord, the panel point spacing and the truss type were critical. After careful consideration, a Pratt truss with a constant sloping roof was selected.

GEOMETRY

Since it is imperative that the operating floor of a paper machine building be open, trusses were used to span over the operating floor. The top chords of the trusses were braced using struts, the bottom chords were braced using bottom chord bracing, and sway frames stabilized the top and bottom chords during erection.

The base plates and operating and mezzanine girders were considered "fixed" in an effort to control building deflection from the racking forces of the cranes, wind loads, and seismic forces induced from the enormous dead load from the precast double-tee panels.

Since deep wide-flange sections are normally used for the lower shaft of stepped columns, the vertical bracing system must brace both flanges in order to consider the column "braced" at that location; therefore, "double-plane bracing" is usually utilized for this application. Essentially, double-plane bracing is comprised of two sets of bracing. One set braces the inside flange of the column while the other set braces the outside flange. The two sets are then "made" integral using lacing or plates. For this particular application, the vertical bracing system was simplified from the "laced up" system. Two WTs, plated together at the ends, were used. By reducing the number of pieces of steel to erect, erection time was decreased.

Floor Live Loading Diagram

Before beginning the analysis of any paper machine building, the "floor live loading diagram" has to be generated. Although this may seem like a simple task, unfortunately, it can be very tedious not to mention time consuming. In fact, the floor live loading diagram is an evolving document (drawing) that does not get completely finished until the analysis and design is essentially complete.

The floor live loading diagram is basically a "roadmap" that outlines the live loads for the operating and mezzanine floor plans. Any special requirements such as reel stand locations, roll lay down areas, and paper machine drive envelopes are also established. The main difficulty creating this document is the never-ending change of a fast track project. The importance of the floor live loading diagram sometimes goes unnoticed. This roadmap must have input and eventual approval from project personnel, staff engineers, and ultimately the client.

The client must not only evaluate the short-term needs, but consideration to future maintenance issues is also critical. The maintenance requirements may be as simple as where to locate a drive aisle for forktruck traffic or as critical as specifying where the parent roll will be placed during routine maintenance. The live loading diagram can have a tremendous impact on the tonnage of steel that is required for a paper machine building.

Analysis and Design

The best way to tackle the analysis of a paper machine is to determine the "area" of the machine where most of the vendor information is known. Usually, this is the dryer portion of the machine. The dryer section is that area where the paper is dried before it is rolled onto a parent roll.

With the floor live loading diagram established for the dryer section, the first in a sequence of three analysis and design models was developed. In this particular paper machine building, there were two expansion joints that conveniently divided the building in three sequences.

To expedite the analysis and design, the intermediate steel (steel which does not contribute to the lateral force resisting system) was analyzed using RamSteel. The beam reactions generated by RamSteel were then entered into the 3-D model as point loads and linear loads.

The main lateral force resisting system was analyzed using STAAD-III. The main lateral force resisting system model consisted of the grid steel (framing located on the column lines), columns, braces, struts, trusses, and bottom chord bracing.

The development of the dead loads, live loads, wind loads, seismic loads, and ponding loads for a typical paper machine building are fairly easy to generate. Crane loads, if done properly, can be time consuming when determining the actual force paths.

Although in AISC Design Guide Series 7: *Industrial Buildings - Roofs to Column Anchorage* it is considered sufficient to distribute lateral crane forces through three building frames, the engineers on this project decided to let the 3-D model distribute the forces throughout the full frame according to the stiffness matrix.

Once the crane loads were determined, the maximum loads were entered into separate load cases for each and every column line. Then, through a series of load combinations, the effects of the crane loads as well as the other loads were addressed. Essentially, the two cranes were stepped through the building, one column line at a time. By approaching the analysis from this perspective, the building was designed for all actual cases, and conservative assumptions that are normally justified for 2-D analysis were eliminated.

Once preliminary sizes were determined, certain parameters were set to "customize" the member sizes. For example, the stepped columns and trusses were grouped to eliminate multiple member sizes. Although steel is purchased by the ton, this type of customization can prevent fabrication and erection errors.

As soon as the member sizes were finalized, the first sequence was "Mill Ordered". Four weeks after the first sequence was mill ordered, the "Released for Construction (RFC)" drawings were completed. Although some member sizes had changed, the impact was minimal.

The second sequence - the winder portion of the building - was the next to be modeled and analyzed. The second sequence model was straightforward because a lot of the information needed to create this model was copied from the first model. The only major difference between the first model and the second was the live loading diagram and the deletion of one bay. The second sequence also contained an endwall whereas the middle of the building did not.

The third and final sequence - the wet end - was the last to be modeled. It was the last because it is usually the portion of a paper machine building where the information is the last to be received. The wet end is very complicated in equipment layout, pipe routing, and structural framing. Similarly, a lot of information could be re-used from the first two sequences to generate this model.

It is highly recommended that paper machine buildings be analyzed and designed in this progression - the dryer section first, the winder section second, and the wet end last. This is the natural flow of information from the vendors, especially the paper machine vendor and this is typically the direction that construction proceeds.

Start-up went so smoothly that it was almost uneventful. Dedication, teamwork, and hard work from vendors, engineering, construction, and especially, the mill personnel combined to bring the S-2 Paper Machine on-line in a mere 18 months and 8 days after purchasing the paper machine—a new record!

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