Concrete & Building in Haiti
Faith Lutheran Orphanage
Report Concerning the March 2016 Trip

As of May 17, 2016
By: Herb Nordmeyer

Introduction

The team consisted of Helen Roenfeldt, Executive Director of Mission:Haiti, Scott Conover, David Vangsness, and Herb Nordmeyer.

We collected in Ft. Lauderdale on the evening of March 10, 2016, and flew to Port-au-Prince on the morning of March 11.

Three reports are filed for this trip:

This one concerns our work at Faith Lutheran Orphanage, first one concerned the activities besides the work in Jubilee and the work at the Faith Lutheran Orphanage.

The second one concerning our work in Jubilee.

Forensic Analysis of the Ceiling of the Boys' Dorm at Faith Lutheran Orphanage – March 20

While the plastering was going on, Lophane, Helen, David, and Herb went to the orphanage to meet Pastor Benoit to perform a forensic analysis of the Boys' Orphanage ceiling, and to mark out the location for the Candice Dominguez Girls' Dorm. They returned to the site in Jubilee about 6:30 pm.

GPS Location of Boys' Orphanage N 19° 26.326 W 072° 40.605
Elevation 44 feet

Wally Bogusat (hereinafter referred to as Wally), Haiti Lutheran Mission Society, Lutheran Church of Canada, had requested that a forensic examination of the ceiling of the Boys' Dorm be performed to determine whether the ceiling could be patched or whether the roof needed to be replaced. He requested that a report be sent to him so it could be discussed at their board meeting on April 17. The inspection was completed on March 20.

The results were worse than anticipated, so Herb sent Wally a brief message to that effect. Later that evening Herb and Wally spent about an hour on the phone discussing details and laying out plans.

A detailed report was furnished to Wally, Pastor Benoit, and Helen. Following is a summary of the inspection and findings.

The Inspection

The initial inspection took place on Sunday, March 20, 2016, beginning at 1:40 pm. Lenz Eitenne, Director, Faith Lutheran Orphanage, and David Vangsness, a Mission:Haiti team member, accompanied Herb during the analysis of the Boys' Dorm. As we proceeded through the dorm, Herb explained what each defect meant.

Later that afternoon Herb took Pastor Revenol Benoit through the dorm and explained the meaning of the various defects and answered questions. Before leaving Haiti, Scott Conover and Herb took our Haitian construction team through and showed them why we were very concerned about doing quality work.

Age of the Building

Lenz stated that he thought the building was 8 to 10 years old. Pastor Benoit said he thought that the building was 12 to 14 years old. A colleague of Wally's stated that the building was in existence in 2001. Helen stated that the storage room on the end of the building was added at a later date.

The Building

This image is a Google Earth photo of the site with markings added to show changes since the photo was taken. Since the photo was taken:

- an additional room has been added on the southeast end of the Boys' Dorm building,
- a fence has been built around the facility,
- a Girls' Dorm has been added,
- a water system has been installed,
- a porch has been added to the front building,
- a building which is shown in front of the Boys' Dorm has been removed,
- a slab and partial walls have been added to the east corner of the fenced property,
- the slab and walls for a kitchen have been added, and
- in March, 2016, the slab was poured for an additional Girls' Dorm.

The Boys' Dorm is set on a Northwest to Southeast axis. The doors are on the Northwest side of the building.

The narrow buildings to the Southeast of the Boys' Dorm and lying in a Northeast to Southwest direction are latrines and a kitchen.

The original building which serves as the Boys' Dorm was nominally 6.7 meters (22 feet) wide and nominally 17 meters (56 feet) long. An addition of approximately 4.7 meters (14 feet) was added to the Southeast end of the building.

Construction is confined concrete block masonry with steel reinforcement. The roof is a flat concrete roof which is steel reinforced and contains low-grade concrete block as space fillers. Mid-height beams in the exterior wall were not installed during the construction of this building.

Concrete beams supporting the ceiling are in the following locations (see assumptions below):

at the top of the front wall,

at the top of the rear wall,

at the top of the end walls, and

approximately every 4.3 meters.

This photo shows the Southeast end of the Boys' Dorm. The buildings to the left in the photo are the latrines. The addition starts just to the right of the door that is shown in the photo. The original structure had ventilation blocks for windows. The addition has a jalousie window in front, but there are no windows on the side or the back.

This photo is typical of areas where plaster and concrete has sloughed off from the ceiling. It shows the strong corrosion of the steel rebar. Note the cracks in the concrete above the rebar. This indicates that the cracking goes deep into the roof structure. Herb pulled some of the roof concrete off by hand and was able to crush it in his hand. He was also able to break sections of the steel rebar. There is no longer electricity reaching the bulb in the center of the room, which provides the only illumination for the room at night.

Concrete block were used as space fillers in the flat concrete roof. This is a typical construction method in Haiti. Many of the block were made with aggregate loaded with clay and were shorted on Portland cement. As a result Herb was able to remove pieces by hand and crush them by hand.

Gently poking the exposed concrete and rebar with his rubber-footed cane resulted in iron oxide and pieces of concrete falling to the floor.

Deterioration of the Roof Exterior

This photo shows the deterioration of the roof from the front of the building. The cracks in the edge of the roof and the underside of the roof overhang show the impact of expanded rebar. On this short overhang, there are not the stresses which develop with the longer spans which are found over the rooms, but the expanding rebar is tearing the roof apart.

Note the rebar sticking up above the roof. The plan for this building, which is common in Haiti, was to add a second story.

Deterioration of the Support Beams and Columns

In confined masonry construction, there are periodic columns. These columns are usually at each corner, on each side of doors, often on each side of windows, and other places so masonry panels are not excessive in size.

Beams are placed on the columns and attached to them so they support the roof above and so they tie the walls together, so the building acts as a unit rather than each wall acting independent of other walls.

With this structure, some of the beams were supported by walls and internal columns. The beams should be attached to the walls, but some of the walls were not attached to the beams. These walls had not remained vertical. As deterioration continues, they are subject to falling.

Several of the beams showed damage from corroded rebar, and Herb was able to crumble some of that rebar. The deterioration of the support beams and columns does not seem as dramatic as the deterioration of the ceiling, but these are the structures which hold the ceiling up. If a failure of a beam or column occurs, the roof will come down.

Note: Photographs which Herb shot with his cell phone of the beam and column deterioration were not focused, therefore are not included in this report.

Note: On the side of the building towards the latrines is a storage room that is locked. We did not go into it during the inspection, but entered it briefly several days later to store items overnight. In the rear, the concrete roof appears to be set on the walls rather than attached to the walls as is done for the rest of the building.

Deterioration of the Walls

The walls were in better shape than the roof. As mentioned before, some of the inner walls were not tied to the roof and were leaning.

This photo shows the peeling paint on the exterior walls. This is a sign that the outer walls have a long-term moisture problem. Peeling paint was covered by paint which peeled, which was covered by paint which peeled. There were several minor cracks in the exterior walls which indicated the corroding rebar problem had started in them.

Discussion

As has been mentioned earlier, at the end of the building towards the latrines is a locked storage room. We did not go in it during the inspection. Later we went in and noticed that the ceiling is in much better shape. Helen Roenfeldt said that the storage room was added after the original building was built. This is the safest room in the building, but was used to store equipment rather than to house the boys.

Pastor Benoit expressed that he wanted the defective roof replaced with a flat concrete roof so they could go ahead and start planning to add a second story to the building.

Herb explained:

(1) If the roof were replaced with a flat concrete roof with steel rebar, the new roof would be failing at some point in the future, probably in as many years as it took the first one to fail, meanwhile the rebar in the walls could continue to corrode.

(2) If the roof was replaced with a flat concrete roof with basalt rebar, the walls holding up the new roof would fail as the rebar in the walls corroded.

(3) The only way to continue to use the building for a few years would be to remove the roof and replace it with a metal roof.

Pastor Benoit then asked Herb to develop a design for a replacement building which would not deteriorate.

Anticipated Path of Building Failure

The ceilings in the original part of the structure will continue to shed plaster and concrete until all of the plaster and concrete has fallen.

With the corroded rebar, the roof is losing its ability to be self supporting. In the event of an earthquake, it will collapse suddenly. In the event of a heavy rain or rain over a period of days, the weight of the roof will increase, and the roof will become more likely to collapse.

On several occasions Herb saw orphans on the roof playing. There are weak areas where a hole could develop in the roof when they stepped hard in an area. Even if the orphan did not fall into the hole or fall through the hole, someone could be injured. Even if no one was injured in such an incident, this could easily lead to more of the roof collapsing.

Separate and apart from the failure starting with the failure of the roof, as the beams and columns deteriorate, as the beams and columns are moved by earth tremors, or as more weight is added to the beams and columns due to accumulation of moisture on and in the roof, a massive failure of the roof is likely. The failure could occur today, or it might not occur for two or three years. The risk is grave.

Conclusions

No orphan should be allowed in any of the rooms where there is ceiling deterioration.

The building has failed and will eventually collapse. The date of the collapse cannot be predicted and can occur in any of the scenarios mentioned in the previous section.

While the foundation appears to be functioning well, an analysis was not made as to whether the foundation could support the weight of a multi-story replacement building.

Follow-up

Herb sent Wally an email after the inspection, stating that the conditions were worse than anticipated. That evening he and Wally talked on the phone for nearly an hour. A report was written and furnished to Wally, Helen, and Pastor Benoit. Wally took it to his board on April 17. On April 19 he went to Haiti. While there, the boys were removed from the dorm and housed in another building. Then the Boys' Dorm was demolished with funds produced through the Haiti Mission Society of the Lutheran Church of Canada. Wally joined Pastor Benoit in requesting Herb to develop a design for a replacement building which would not deteriorate. Herb is working on that.

Explanation of Deterioration of Rebar

This explanation will probably make the eyes of most readers glaze over. It is included because there is a serious problem in Gonaives, Haiti, and many other parts of Haiti that is not being addressed.

Non-reinforced concrete is high in compressive strength, but low in tensile strength. Reinforcing is added to concrete to increase the tensile strength. The most common method used is to add steel rebar. In most situations this is adequate. The two most common problems with the use of steel rebar is when chlorides are present, as when salt (sodium chloride) is added to a roadway for deicing, and when water can get to the rebar.

When chlorides are in contact with steel, and there is enough moisture present for a chemical reaction to take place (enough moisture to dissolve some of the sodium chloride), several chemical reactions take place. First, when the salt dissolves in the water, the ability of the water to carry an electrical current is increased. This increases the ability of the oxygen that is dissolved in the water to react with iron which is in the steel rebar. In the process, ferrous oxide, ferric oxide, ferrous chloride, and ferric chloride can be formed. The oxidation state of the iron (ferric or ferrous) and whether a chloride or an oxide are formed are not germane to this issue, since each of those chemical compounds increases the volume of the iron in the steel which was the precursor for those compounds.

When the rebar expands as these compounds are formed, stress is developed until that stress is greater than the tensile strength of the concrete. This causes the concrete to crack. The cracking of the concrete allows more water and oxygen to come in contact with the rebar and the chlorides which are present. This accelerates the process.

The stresses the concrete has been under usually weaken the concrete in areas around any of the cracks which occur.

As the chemical reactions continue, the tensile strength of the rebar decreases. This causes the tensile strength of the concrete to decrease.

When a concrete beam or slab is suspended between multiple supports, it flexes very slightly. At a point between any two supports, the bottom side of the beam is under tension and the upper side is under compression. Above any of the supports, the top of the beam is under tension and the bottom of the beam is under compression.

As a result, a flat concrete roof will often crack above any supports and will sag between those supports. The cracking above the supports increases the moisture entering the roof and accelerates the deterioration.

In the Gonaives, Haiti, region, there are several other factors which contribute to the problem:

The water used for mixing much of the concrete is often brackish. This provides the chlorides to increase the oxidation of the steel.

Much of the aggregate used contains clay. Tests Herb has conducted have shown up to 29% clay in concrete sand on our jobs in Haiti. The presence of clay requires more water to be added to make the concrete, stucco, or mortar workable. The increased amount of water needed increases the amount of chlorides which are available to catalyze the oxidation reaction.

The concrete is often porous due to aggregates used which are not well graded to increase the density of the concrete mass.

The concrete is often not well consolidated, leaving air pockets in the concrete as reservoirs of oxygen and water.

The clay in the concrete acts as a reservoir for the chlorides, so the chlorides can initiate a chemical reaction whenever the moisture content of the concrete is conducive to the oxidation reaction.

Candice Dominguez Dorm

GPS location: N 19° 26.309 W 072° 40.593

Layout of the Site – March 20

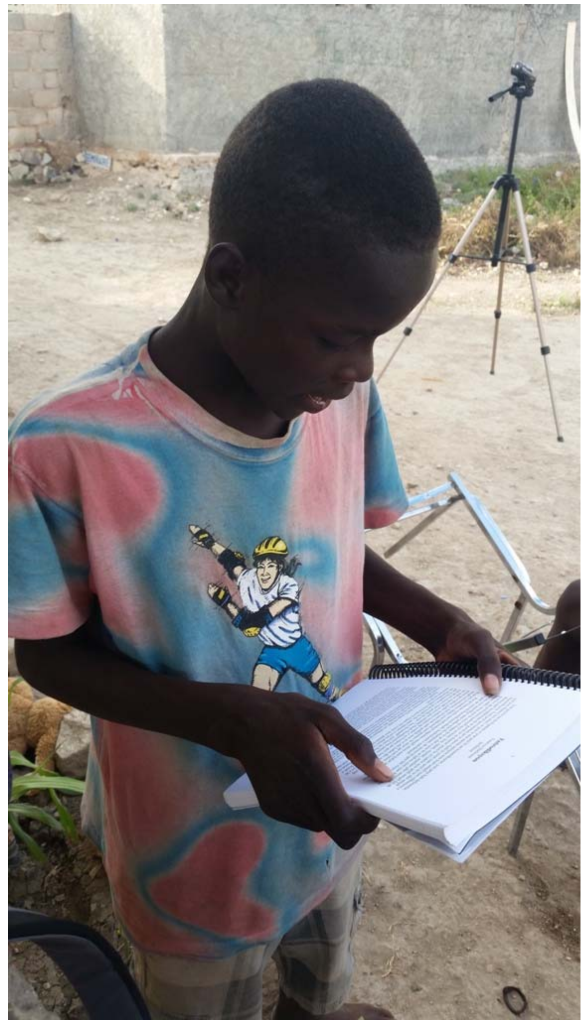
After completing the forensic analysis of the Boys’ Dorm, we marked the center point for the Girls’ Dorm. Even though we had been assured that the site would be cleared before we arrived, the area was overgrown with brush and trees up to 2.5 inches in diameter.

We selected a center point so the dome would be 15 feet from the kitchen and five feet from the dividing wall between the Boys’ Orphanage and the Girls’ Orphanage.

Installing the Forms – March 21

As soon as a few people could be spared, they were sent to clear the site for the dorm. An hour later Herb followed. One of the orphans studied the book, Kay pou

Jubilee to make sure we were doing it right.



Laying out an EcoShell is predicated on selecting a center point and measuring everything from that center point. To make the layout easer, we would drive a pipe into the ground and then mount fittings, ending in an elbow. Attached to the elbow would be a length of PVC pipe with marks and holes so designate specific locations, such as the outer edge of the footings, the outer edge of the Airform, etc. We purchased 3 PVC fittings we needed. When we opened the bag to use them, we found that even though the receipt said we had the right fittings, we had the wrong fittings. While another trip was made to the store, the fittings we had were placed in a safe place. When we needed them, it took quite a while to remember where that safe place was located.

We set the outer form stakes using a string line to measure and set the inner form stakes using a measuring stick. Leveling was done using a string level from the center pivot post and with a two-foot level between posts. After going around the circle, the stakes, where they met on the back side of the circle, were about 4 inches different in height. Needless to say, this required re-leveling all of the stakes.

Herb calculated the amount of backfill, sand, gravel, and Portland cement we would need, and then Lophane placed the order. Herb can calculate in cubic yards and cubic meters, but the aggregate is sold by the truckload. Truckloads vary in size. Herb calculated we needed 3 loads of backfill, one load of sand, and two loads of gravel. He also calculated that we would need about 50 bags of Portland cement. The backfill estimate was accurate. The sand estimate was accurate, but we ended up with three loads of sand rather than the one we needed. The gravel estimate was a little high, and the Portland cement estimate was very low.

We got a load of excellent sand delivered. Seemed like a very small load. Then two loads of excellent gravel were delivered. They were much larger loads. Then we received another load of sand. This one was the same size as the loads of gravel. After that we got three truckloads of base material (backfill or fill) delivered. Herb had wanted the fill we had used before, but this fill contained lots of boulders. It worked fine, but it was harder to move from the pile to the area where it was needed. The deliveries were over the big part of two days.

In time the double row of form boards were installed, and Scott had to go back with the level and determine why the top of the form boards was not level. He directed the correction.

We were hampered because we had only one wheelbarrow. The second wheelbarrow was still in Jubilee even though it was not being used. About quitting time, Herb finally threw a tantrum. Rochenel assured Herb that the second wheelbarrow would be delivered before Herb got to the site on Tuesday morning.

With about half the fill added, it was approaching dark, and we returned to the Guest House.

Preparing the Forms to Receive Concrete – March 22

We got to work moving base material into the center of the form boards. The second wheelbarrow had arrived. It was broken. Apparently it had been left in Jubilee because it was broken, and no one wanted to tell Herb that it was broken. Herb gave Lophane the money, and Lophane went and bought a replacement. The broken one can be fixed, but that would take more time than buying a new one, and we had run out of time.

We installed 16-inch-long pieces of 6 mm basalt rebar through the form boards for the foundation at 5-foot intervals. The lower one was about two inches from the bottom of the footing. The upper one was about two inches from the top of the footing. These pieces of rebar served as chairs to support the rebar that was placed in the footings. By tying everything, we ended up with a solid matrix of rebar to reinforce the footings. In the future we will place the “chairs” at 2.5-foot intervals rather than at 5.0-foot intervals.

With the footings being 30 feet in diameter, they took about 96 feet of rebar per loop. With 4 loops, that was nearly 400 feet of rebar. Adding approximately 40 short pieces to support the long lengths of rebar added another 50 feet. We ended up using the biggest part of two 100-meter coils of rebar for the footing.

Unrolling the rebar is an interesting challenge. The coils are about 4.5 feet in diameter and spring loaded. Ends of the rebar often whip around. The person holding the coil is safe, but a person standing 10 or 15 feet away can be slapped pretty hard.

Another problem with unrolling the rebar is picking the end that is on the outside of the coil and starting the unrolling with that end. Sounds simple, but often it is not. When the wrong end is selected, it is like trying to unroll a spool of thread from the center. The rebar ends up in knots. Of the 6 rolls we unrolled, Herb selected the wrong end twice.

When the base material was initially being transported to the center of the forms, a gap was left in the inner and the outer form boards so a wheelbarrow could enter. Some of the base material was transported in by bucket. When Lophane returned with the replacement wheelbarrow, the process speeded up.

In adding base material Herb was not able to get across that we did not need to fill with base material way beyond the top of the inner form boards. After the compacting started, there was a lot of extra work that had been done that had to be undone.

Scott was in there with measuring lines and a shovel showing them what needed to be done. He did not depend on a translator to explain. He showed, and he showed, and he showed. When the extra base material had been removed, and the remaining base material was compacted, we ended up with a reasonably level area for pouring the slab.

We needed to add a vapor barrier under the concrete, so that in the rainy season the concrete slab the girls would be living on would remain dry.

The polyethylene vapor barrier was still missing, so Herb sent Lophane to buy plastic tarps to use instead. Rolls of polyethylene are not sold in Gonaives. The roll we had had cost us about $100 in Port-au-Prince and was enough for multiple slabs. Blue tarps for this one slab cost us $200. They were placed and weighted down with rock.

For a 20-foot slab, we place the rebar 18 inches apart both directions. Since this slab was 30 feet in diameter, Herb opted to place the rebar 12 inches apart.

It was placed, and rather than tie the laps, Scott showed the crew how to weave the rebar into a mat. It took 4 coils of rebar to complete the slab. Each end of the rebar in the mat was tied to the outer rebar loop.

We used about 600 meters of 6-mm basalt rebar for the footings and the slab.

The mixer had not been moved from Jubilee like we were assured would happen. None of the vehicles the team was using had an appropriate hitch to tow the mixer, so Lophane hired a trucker to haul it to the Orphanage. This cost us $50, which was an expense we had not anticipated.

Scott built a ramp so we could go over the form boards with a wheelbarrow without damaging the form boards. The ramp included a large rock which fit between the inner and outer form boards and was just the right height to come level with the outer form board.

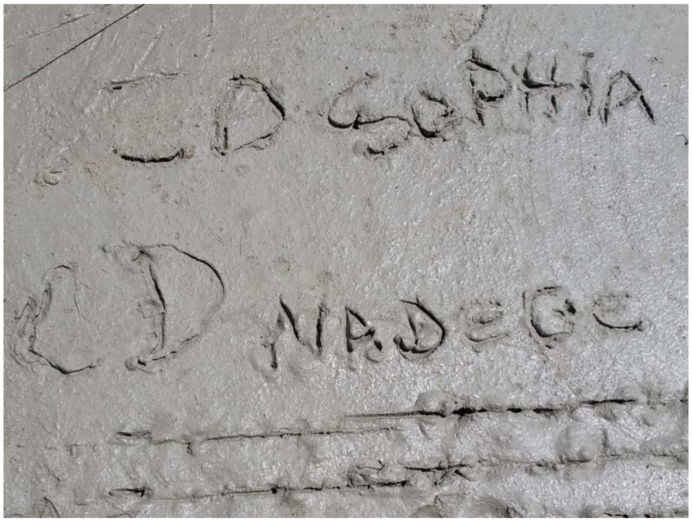
Pouring the Concrete – March 23

With aggregate meeting ASTM standards, determining the ratio between large aggregate, sand, and cement is easy. Look it up in a book. In Haiti experimentation is required since the aggregate available does not meet ASTM standards.

Herb sat down at the intersection of the sand pile and the gravel pile with a 5-gallon bucket and demonstrated how to come up with a ratio of sand and gravel which produced the densest aggregate mix (a dense aggregate mix results in the strongest concrete with the least amount of Portland cement). The process is simple. Place a measured amount of gravel in a bucket. Then add measured amounts of sand until all of the gaps between the gravel are filled. To ensure that no mistakes were made, start over and add the determined amounts of sand and gravel to the bucket and mix. If it comes up with the gaps filled and no extra sand, you did not miscalculate during the initial process. Herb determined that for each bag of cement we needed 2.75 buckets of sand (4-gallon buckets) and 5 buckets of gravel (4-gallon buckets). Looking at the mix after it had set, Herb concluded that we could have added a little more of the aggregate blend.

When we had arrived at the site, Scott's ramp had been removed, and the mixer was set to pour into the footing cavity. Scott and the crew spent nearly an hour coming to a compromise as to what was the best way to move the concrete. That compromise was modified about every hour during the day. There was a time when the concrete was placed in a wheelbarrow with the wheelbarrow on the filled material inside the footings. There was a time when the wheelbarrow was outside the footings and wheeled over a makeshift ramp. There was a time when the concrete was dumped into a wheelbarrow and scooped up into buckets and passed across the formed area. At no time was the mixer ever leveled, so when dumping a load, it wanted to dump onto one of the mixer tires rather than into the wheelbarrow that the crew was aiming for. If the mixer would have been leveled, or if it had been turned around so it would dump from the other side, the problem would have been corrected. There were too many conflicting opinions flying around, and there was not a strong crew leader, so Herb went off and played with the children.

As the concrete was being placed, there tended to be a bulge between the center stake and the outer form. We tried to minimize that, but were never able to get it eliminated completely. This resulted in the concrete near the center point being 2.5 inches thick. The concrete near the outer form was 2.5 inches thick, and the concrete in between ranged from 3.5 to 4.0 inches thick. There was also an area where the inner form was low (where the outer form level had had to be adjusted), and the concrete ended up being 5 inches thick rather than the design thickness of 2.5 inches.



After the first concrete had been consolidated, screeded, and floated, the girls from the Orphanage were assembled. Helen gave each of them a photo of Candice and talked about how Candice was sick and could not come on this trip, but planned on returning next year. All of them remembered the piñata lady. She asked them, “Would you like to carve Candice’s initials into the concrete?” The responded, “Yes, but what were initials?” We ended up with CD for Candice, and then each would write her name. To show them what was needed, Herb placed “CD” and “Herb” on the back of a photo, showed them, and then carved “CD” and “Herb” into the slab. At that point, Herb stepped back to the video camera, and Lophane took over helping the girls. With one of them, he held her over the concrete so she could reach the area to carve. When she had a problem, he held her with one hand and guided her hand with his other hand.

After the carving, the girls went about their business.

By the time a fourth of the slab had been poured, it became evident that the original estimate of 50 bags of Portland would not be enough, so Lophane brought in 20 more bags. As the pour continued, Herb estimated the amount poured and counted the used bags and determined that we would need a total of 58 bags. Scott then pointed out that some of the used bags had been removed from the site (recycled?). By counting the bags of Portland which had not been used, Herb concluded that his estimate was off. We purchased 95 bags and had 6 left over, so we used **89** bags.

There is an area between the Boys' Orphanage and the Girls' Orphanage which collects water. Scott and Herb agreed that is a 5-bag job, so 5 of those 6 bags will be used for the walkway.