AC 2012-5288: COLLEGE AND INDUSTRY PARTNERSHIPS: THE SAM, TANZANIA POLYTECHNIC, AND WELD QUALITY

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College and Industry Partnerships: The Samé, Tanzania Polytechnic and Weld Quality

Introduction

A sustainable solution for the built environment is a solution that "meets the present needs without compromising the ability of future generations to meet their needs" [1]. Such solutions require the use of appropriate technology and resources, and consideration of the local environment. For the developed western world, sustainable solutions can be seen in such buildings as the San Francisco Federal Building. This solution was embodied in a building design that matched advanced technology of a developed nation to the specific climate conditions of the project location. The engineers were able to design a mechanical system that saved $500,000 in annual operational cost [2]; a lighting design that allows for approx. 85% of the office space to use natural light; and a structural system that incorporated recycled materials (blast furnace slag) [3].

When considering an underdeveloped country and a building in the rural areas, what would a sustainable solution look like? In order to obtain the sustainability goal of allowing future generations to meet their needs, a solution must be in the form of the local resources – materials, tools, labor skill sets, education and economics. To tackle this challenge, a collaboration of academia, industry, and a non-profit non-governmental organization (NGO) was formed. The collaboration allows the resources of college students partnered with oversight of industry, to provide design solutions virtually fee free to the non-profit NGO. Such a partnership allows for direct and real world experience education for the student; allows for humanitarian contributions and knowledge transfer for industry; and allows for economical sustainable solution for the people (via the non-profit NGO). The team works under the banner of

"to help people on their terms – not ours – think globally and solve locally".

This paper addresses the symbiotic relationship of a College and Industry Partnership in a global experience and how student learning benefits all parties involved. The symbiotic partnership is between the University, a non-profit non-governmental organization, and an international multi-disciplinary engineering and design firm. The partnership is in its fifth year. The current focus (project) of the partnership is on the planning, design, and construction of polytechnic school for the people in rural area of Tanzania. An example of student learning is given through the specific student research project investigating the weld quality in the rural areas. The student research was conducted as a senior project.

Project Background – Samé, Tanzania Polytechnic

The site for the Polytechnic School is located to the north of Same, Tanzania (Figure 1) and on highway B1 (the main route through Tanzania). The town has a population of approx. 17,000 and is a stop for the national railway network (Tanga line). The town is essentially a gathering and distribution center for the people of the rural area. The main commerce is tourism and churches.

Recently the United Republic of Tanzania has taken measures to provide high quality education [4] for its people. The measures are part of the *Vision 2025* strategic plan [5]. The plan mandates that all students graduate from secondary school. However, secondary school curriculum does not provide vocation training or means of acquiring job skills. In order to provide an opportunity for the graduates of secondary education to obtain job skills, the Catholic Diocese in Samé, Tanazania is proposing to build a 1000 student polytechnic school for the rural population.

Figure 1: Samé, Tanzania

The poor economic rural location combined with the undeveloped nation status of Tanzania [6] has left most of the population to construction buildings with little to no oversight or regulation conformance. The Catholic Diocese recognizes the deficiencies in the construction knowledge and methods, and realizes the deficiencies are due to the lack of knowledge and the limitation of resources. A secondary goal in the construction of the polytechnic school is to transfer information and technology to the rural people and to raise the quality of the built environment. In this secondary goal, the school can show the world what the people of Tanzania can do, despite their economic level. And it is to be a stepping stone for the people themselves to build similar quality buildings.

In addition, the poor economic conditions translate to the Catholic Diocese and thus challenge the dream of how to realize the polytechnic school when there are essentially no monies available. Such things as site assessment (i.e. surveying and documentation) and initial planning (master planning for crops and master planning for buildings) cost money. Documents of assessment and planning are needed for permitting and fund raising. Overall project management and oversight is required from conception to completion. These items require experience, professional skills and money. How can all of this be accomplished with little to no upfront funding? The answer is a partnership - a partnership of mutual benefit.

College students from universities can provide the energy and labor; industry can provide the experience and professional qualities; and a non-profit NGO can provide the management and liaison communication from conception to completion. This partnership can make significant contributions to the project at minimal upfront cost (comparatively) and freeing up the Diocese to concentrate on raising funds (with the professional documents from the partnership).

College-Industry-NGO Partnership

The partnership works on a year-long time line and dovetails with the academic year of the students. The start of the time line is the summer (when school is not in session) and when the partnership identifies needs and defines roles and goals for the upcoming year. The students are the driving force where their work and deliverables are used by the NGO. The student's work has oversight and approval from industry. Industry acts in a mentor role for the students.
At the beginning of the school year (Fall) interested students are organized in a "design office" model. The faculty acts in a capacity similar to a design office managing partner and have

responsibility for quality and accuracy of the students work. The students are divided up into teams where individual needs of the NGO are assigned - office projects. Each project team elects a leader – a project manager. The size of the teams ranges from 1 to 6 students; depending on how the students are going to receive university credit (design studio, special projects, senior project, or simple volunteer). The faculty and lead students have direct contact with the industry. Periodic meetings are required for progress report, updates, and team building.

Meetings are set-up with industry at the beginning, middle, and end of the project period. The meetings are at the industry partner's office and usually last a whole day (8 hours). Students are required to send material a week ahead of the meeting so the industry partner can prepare. At the meeting the students make a project status presentation, obtain feedback, are given direction, and then "buy-in" to an up dated schedule and deliverables.

The main template is as follows;

- During the summer, the University, Industry, and NGO representatives meet to discuss the needs for the up-coming year.
- During the fall, a venue for student participation and opportunities is created. The typical venue is a seminar class where students are organized into interdisciplinary teams. Each team is given a need that was determined during the summer. The students run the team (opportunity for leadership) with oversight.
- The NGO and industry meet periodically with university.
- Progress is monitored; deliverables are continuously assessed.
- During the spring, deliverables are presented to the NGO and if possible to representative of Catholic Diocese of Tanzania.
- Catholic Diocese makes an annual visit (as resources permit)
- Funding is sought and if procured, student travel to site is organized. Some deliverables involve travel to the site (e.g. surveying).
- During the summer, work is assessed and plan for next year developed.

This article will use a student's senior project on the weld quality in rural East Africa as an example of the type of topics investigated.

Weld Quality in Rural East Africa – the Need for Quantification

It was identified by the industry partner (summer of 2009) that it would be helpful if the weld quality and capacities in Rural East Africa were quantified. Traveling to the site and testing the welding was beyond the finances of the project. In the Fall of 2009, one of the topics for the students to investigate was the weld capacities through experimentation. A student's senior project was perfect for the task.

The experiment would simulate poor quality welding by someone with good intentions and with no oversight (e.g. inspections or defined procedures). To simulate the poor weld quality a student with no prior welding experience was given an hour long lesson [7,8,9,10] in welding prior to welding the specimens. Additionally, poor welding conditions were simulated by using scrap metal which had been exposed to the elements (rusted).

The skill level of welding was reproduced by using students who had no welding experience. Control welds were made by professional welders. The specimens were exposed to weather prior to welding.

The college-industry partnership through a student's senior project was able to gain insight to weld strengths in rural East Africa. The results indicated that ultimate values used in U.S. codes should be reduced by 50% and then factors of safety applied. Also, visual inspection can have a benefit when compared to the absence of quality control.

Student Expectations

The student who performed the experiment did not have any prior welding experience, and took the project on to

- contribute to a humanitarian project in Tanzania;
- to learn to weld;
- to see how the engineering equations compare to actual values;
- to learn about the issues in welding and experimentation; and
- to fulfill requirement of a senior project.

The student expectations were

- learning to weld and welding itself would be the most difficult part of the experiment;
- setting up the test would be simple and straight forward;
- documentation would not be time consuming;
- the welds would fail as the "book" states – at the throat of the weld;
- the student welds would fail at value below codes; and
- the professional welders would have the best welds (at code or above).

What the student experienced was

- learning to weld was easy;
- preparing the material (grinding away rust) was time consuming;
- while the test procedure was simple, preparing everything for testing took much more time than expected.
- documentation took much more time than expected;
- the welds did NOT fail where the "book" stated;
- weld values were in-line with expectations;
- the professional welds performed better than code values;
- in addition to learning how to weld, the student learned what constitutes a good or bad weld;
- the experiment "sparked" the students curiosity, to quote the student, "The defect that sparked my curiosity the most was porosity."; and
- there were consistent values of the inferior welding and a conclusion could be made.

The Welding Experiment

The experiment consisted of 13 steel specimens. Each specimen consisted of four plates with four fillet welds (Figure 2). The plates were scrapped pieces of metal that had been exposed to the elements. The type of steel was unknown and the plates were thoroughly rusted. The plates varied in size between 1/4" and 1/2" thick and the lengths were cut down if necessary to fit usable specimen lengths.

The welding was Metal Inert Gas (MIG) welding, also known as Gas Metal Arc Welding (GMAW). The welding used a gas shield of CO_2 and Argon to protect the molten metal from oxygen and other harmful gases. The welding electrodes were ER70S-6. The welds were all to be 3/16" fillet welds, though the actual sizes varied from 1/8" to 1/4".

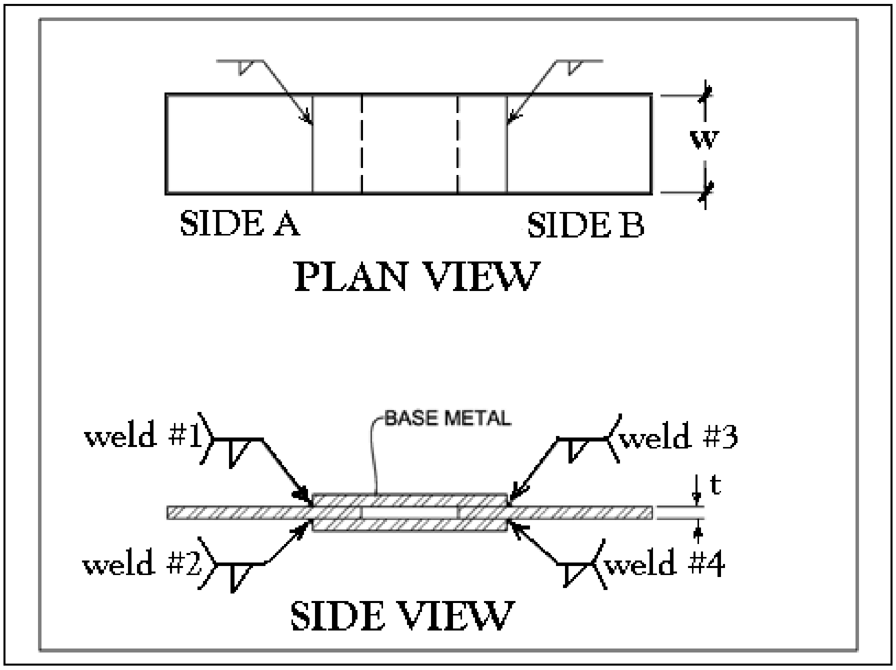

Figure 2: Specimen setup.

The test focus was on the strength of welds made by an inexperienced welder as compared to code specified strengths. Eight specimens were made by an inexperienced welder on prepared plates (rust removed). Two specimens were made by an inexperienced welder on non-prepared plates. Three of the specimens (1A, 3A, 3B) were made by experienced welders as control welds.

The non-prepared plates were welded to simulate the lack of quality in rural East Africa.

The numbering system of the specimens indicated the day on which the specimens were made (1 for the first day, 2 for the second).

To duplicate the low welding skills, the inexperienced welder was a student with no prior welding experience who received a short lesson (approximately 1 hour) with 6 other people to learn the basics of how to use the equipment safely. After the class the student practiced a minimal amount (only 3 or 4 lines of welding) before starting to weld specimens.

The rusted material was ground down to bare metal (prepared surfaces). Each weld was made with a single pass and extended the entire length of the joint. It is noted that the welds were

made consecutively (1,2,3 then 4). The sequential welding preheated the base metal for all but the first weld on each specimen (Figure 3). Pre-heated metal can play a role in the quality of a weld made, generally for the better because more uniform heating and slower cooling rates can cause lower residual stresses in both the base and weld metals. Pre-heating will not necessarily occur in the field, so it is worth noting that this can be cause of discrepancy between the test results and actual strengths in the field.

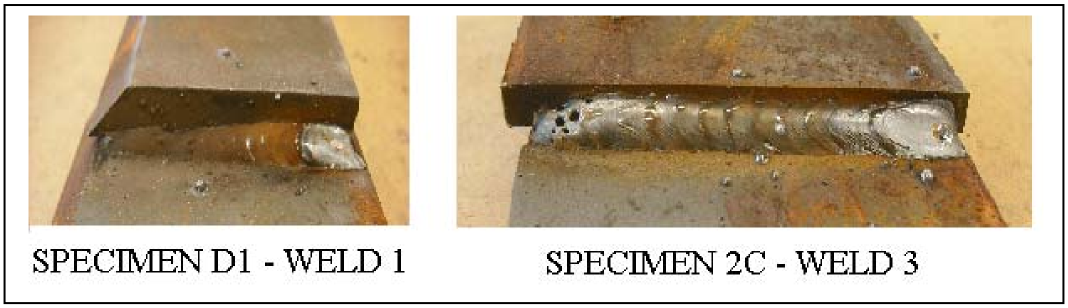

Figure 3: Example of Low Quality Welding

The Welding Testing Results

Testing was uni-axial testing in a universal testing machine. Nearly all of the welds failed at the weld-base metal interface. The graph below (Figure 4) show the tensile failure load (R_u) of each specimen normalized to the code value (R_n), where the code value used 70 ksi as the ultimate value.

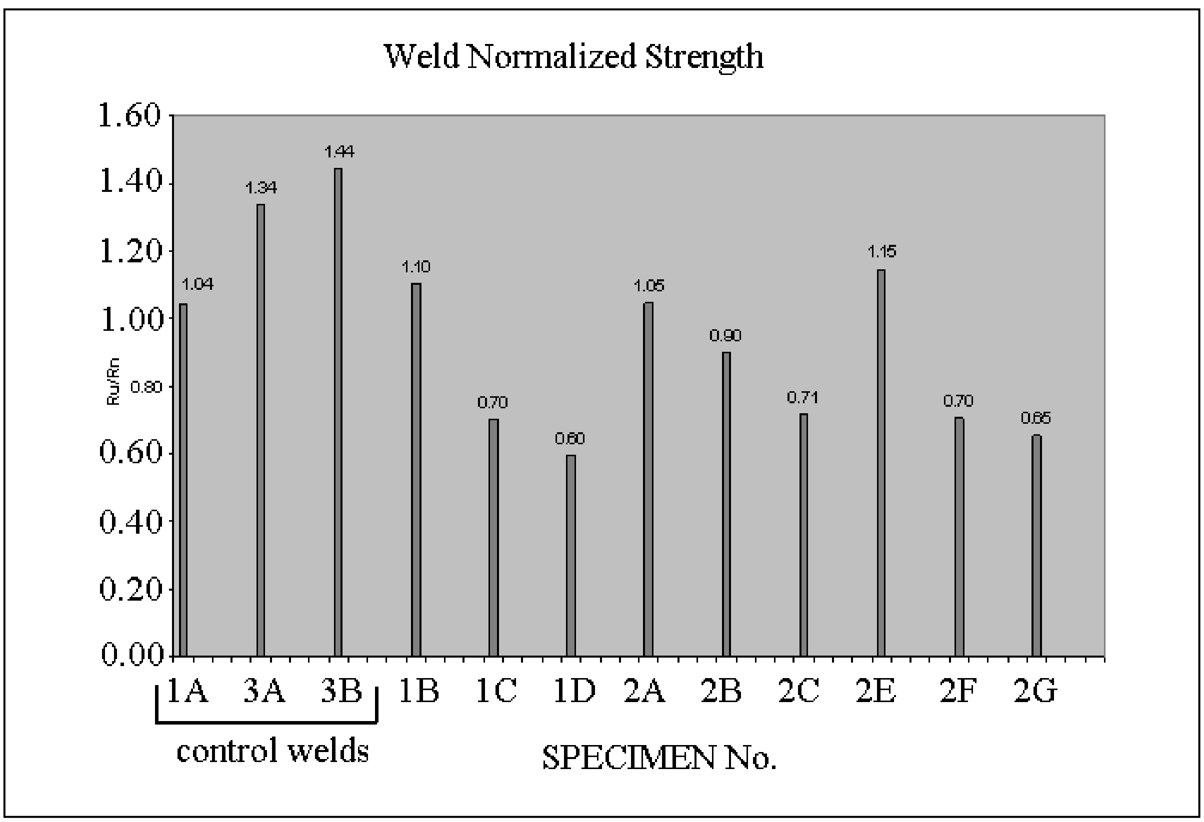

Figure 4: Uni-axial Tension Test Results

In Table 1 (below) has summary of the specimen physical properties and the test results. Side A refers to the side with welds 1 and 2. Side B has welds 3 and 4. The specimens are listed in order that they were constructed. The control welds (welding preformed by professionals) are specimens 1A, 3A, and 3B.

Table 1: Specimen Physical Properties and Test Results

Specimen	Base Metal Thickness	Weld Location	Size (in)	Length (in)	Expected Strength for Individual Welds (kips)	Side Name	Expected Strength for Specimen (kips)	Measured Ultimate Strength (kips)	Ru/Rn	Expected Side of Failure	Side of Failure
1A	1/2 "	L 1	0.25	2.63	32.5	A	57.2	59.75	1.04	B	B
		L 2	0.25	2.75	34.0						
		L 3	0.25	2.75	34.0	B					
		L 4	0.19	2.50	23.2						
1B	1/2 "	L 1	0.19	2.50	23.2	A	48.7	53.75	1.10	A	A
		L 2	0.19	2.75	25.5						
		L 3	0.19	2.00	18.6	B					
		L 4	0.25	2.50	30.9						
1C	1/2 "	L 1	0.19	2.75	25.5	A	46.4	32.50	0.70	B	B
		L 2	0.19	2.38	22.0						
		L 3	0.19	2.50	23.2	B					
		L 4	0.19	2.50	23.2						
1D	1/2 "	L 1	0.19	2.63	24.4	A	44.1	26.25	0.60	B	B & A
		L 2	0.19	2.31	21.5						
		L 3	0.19	2.50	23.2	B					
		L 4	0.19	2.25	20.9						
2A	5/16"	L 1	0.19	1.81	16.8	A	35.4	37.00	1.05	A	A
		L 2	0.19	2.00	18.6						
		L 3	0.25	2.25	27.8	B					
		L 4	0.25	2.13	26.3						
2B	5/16"	L 1	0.19	2.06	19.1	A	38.9	35.00	0.90	A	B
		L 2	0.19	2.13	19.7						
		L 3	0.25	2.00	24.7	B					
		L 4	0.19	1.94	18.0						
2C	1/4"	L 1	0.19	2.44	22.6	A	47.6	34.00	0.71	B	B
		L 2	0.25	2.88	35.6						
		L 3	0.19	2.50	23.2	B					
		L 4	0.19	2.63	24.4						
2D	1/4"	L 1	0.19	2.81	26.1	A	51.0	39.25	0.77	A	Base Metal Failure
		L 2	0.19	2.69	24.9						
		L 3	0.25	2.81	34.8	B					
		L 4	0.19	2.81	26.1						
2E	3/8"	L 1	0.25	2.38	29.4	A	45.8	52.50	1.15	B	B
		L 2	0.19	2.44	22.6						
		L 3	0.19	2.50	23.2	B					
		L 4	0.19	2.44	22.6						
2F	1/4"	L 1	0.19	2.38	22.0	A	42.9	30.25	0.70	A	B
		L 2	0.19	2.25	20.9						
		L 3	0.25	2.38	29.4	B					
		L 4	0.25	2.38	29.4						
2G	1/4"	L 1	0.19	2.81	26.1	A	52.8	34.50	0.65	A	A
		L 2	0.19	2.88	26.7						
		L 3	0.19	2.75	25.5	B					
		L 4	0.25	2.63	32.5						
3A	3/8"	L 1	0.13	3.50	21.7	A	44.1	59.00	1.34	A	A
		L 2	0.13	3.63	22.4						
		L 3	0.13	3.69	22.8	B					
		L 4	0.13	3.88	24.0						
3B	3/8"	L 1	0.13	3.56	22.0	A	45.2	65.25	1.44	A	A
		L 2	0.13	3.75	23.2						
		L 3	0.13	3.63	22.4	B					
		L 4	0.13	3.75	23.2						

Conclusion

The conclusion from the testing was that the capacity of the welding in rural East Africa may be taken as 50% of the capacity calculated by U.S. codes, and a safety factor should be used in addition to the 50% reduction. Also, in order to increase confidence in the results further research should be conducted. First and foremost additional research would be to increase the number of data points of inexperienced welders. Also research can be done on the effect of welding conditions such as temperature, humidity, and wind. Preheating is another issue that could be researched further to determine the significance to weld strength and the amount of fusion between the weld material and the base metal.

In regards to the College-Industry partnership, this was an example of a successful partnership. The industry did not have the time resources to commit to the project, but needed an indicator of probable capacities. Because of the partnership, industry obtained information and the student gained experience and insight to welding and what makes a poor weld, while contributing to a real world project.

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