Santa Rosa Junior College Student Center

Santa Rosa, California

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April 13th , 2010 – Construction Management Option - Faust

Presentation Outline

- Bertolini Student Center Background
- Theme of Senior Thesis
  - Industry Issue: Renewable Energy
  - Analysis 1: Alternative Prefabrication Process
  - Analysis 2: Alternative Façade Design
  - Analysis 3: Alternative Steel Erection Process
- Conclusions
- Questions

Santa Rosa Junior College

- Located in Sonoma County, California
- Designed as a public, 2 year college
- 2 campuses: Petaluma campus, and Santa Rosa campus
- 2008 enrollment of 36,460 between two campuses

Student Center Project

Project Information

MIDSTATE CONSTRUCTION
Building Relationships

- **Size:** 66,646 SF, 3 Stories plus attic
- **Construction Dates:** December 3, 2007 – November 24, 2009
- **Cost:**
  - +/- $30,000,000 Midstate Construction
  - +/- $20,000,000 Mechanical, Electrical, Geothermal

Thesis Topic Overview

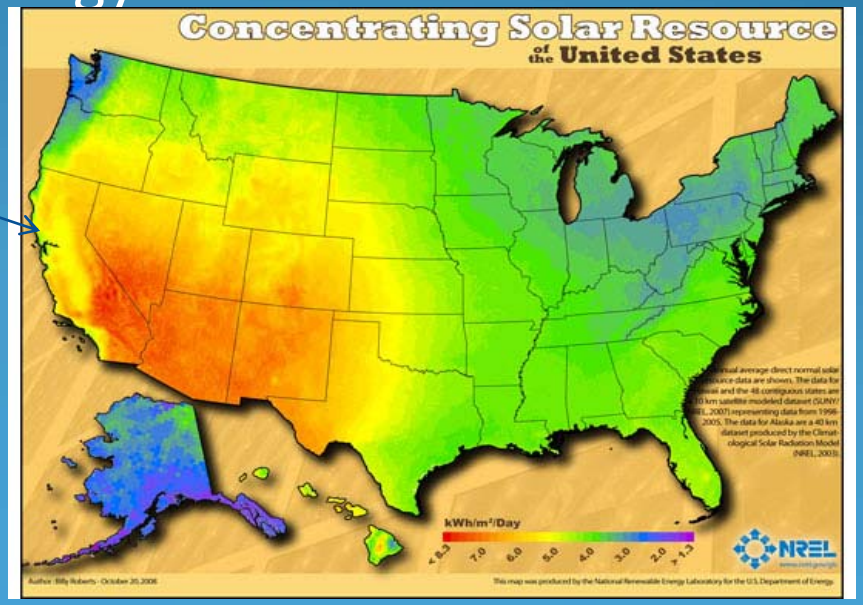
1. **Industry Issue: Building Integrated Renewable Energy System**
2. **Alternative Prefabrication Process**
3. **Alternative Façade Design**
4. **Alternative Steel Erection Process**

Industry Issue: Renewable Energy

- **Problem:** Energy overconsumption and diminishing resources resulting in increased energy costs worldwide.
- **Goal:** Develop a plan that would implement the use of building integrated renewable energy technology as a means to reduce overall energy costs for the SRJC.

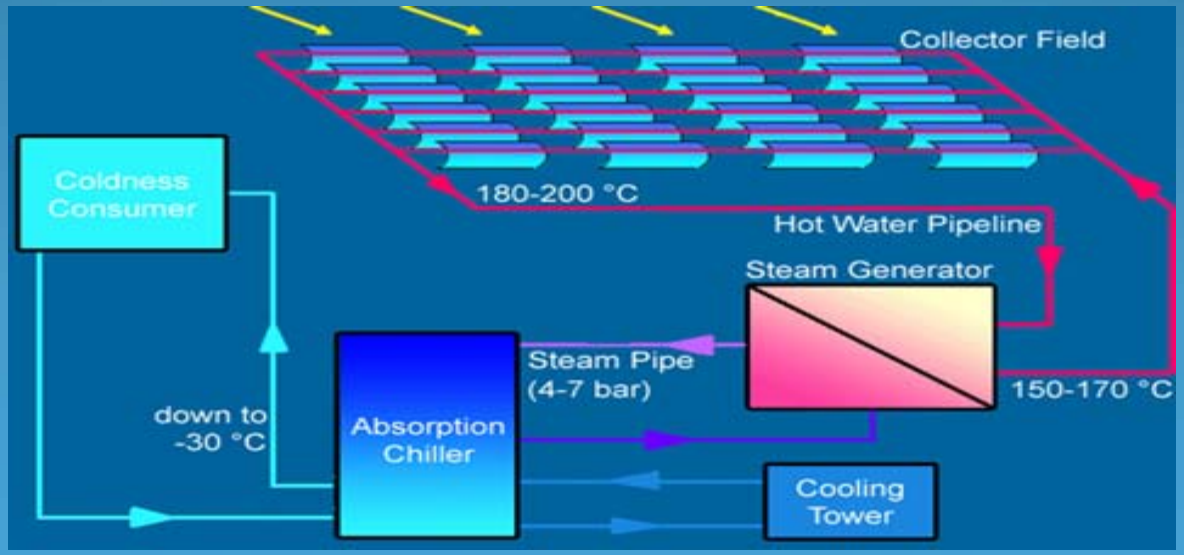
Santa Rosa, CA

Santa Rosa's geographic location makes it a candidate for solar technology.



Absorption Chiller Technology

- Absorption refrigeration systems utilize heat instead of electricity to generate energy.
- Solar collectors are used in combination with the absorption chiller.
- Ferdinand De Carre' developed the system in France in 1890.
- Costly up front price but offers long term benefits in energy savings.



Geothermal Loop vs. Absorption Chiller

- $1,500,000 existing geothermal loop provides entire space heating/cooling demand for the building (290 Tons)
- Current design utilizes no other sustainable features
- Being located in an area that receives a lot of sun, it would be beneficial to utilize solar panels in some way.
- Absorption chiller system with solar array may be able to provide additional benefits as far as energy savings.

Geothermal System Analysis

- Santa Rosa Solar Exposure = 5.45 kWh/m^2/day
  - 3 Assumptions:
    - 1) .95 inverter inefficiency factor
    - 2) .95 factor of soiling, module, and utility inefficiencies
    - 3) .89 weather impact on inefficiency
  - (365days/yr)(.95)(.95)(.89)(5.45 solar exposure)= **1,597 kWh for each kW** installed annually
- Student Center heating/cooling demand = 290 Tons = **1019.89 kW**
- Total Annual Demand
  - = (1,597 kWh/kW)(1019.89 kW) = **1,628,764.33 kWh Annually**
- Average retail cost of electricity in California = $.14/kWh
- Total current annual savings from geothermal loop

  = ($.14/kWh)(1,628,764.33 kWh yearly) = **$226,398.24 Annual Savings**

Solar Collector Analysis

- Total Collector Area needed to meet 290 Ton demand
  (1 m^2/1597 kWh per kW)(1,628,764.33 kWh/year)(1 year) = **1,019.89 m^2**
- Collector Model : "Seido 1/5 – 16AS" produced by Sunda

Feature	Catalog Data
Dimensions	2232x1940x187mm
Gross Collector Area per unit	4.33m^2
Net Absorber Area per unit	2.77m^2
Weight per unit	100 kg
Inclination Angles Available	15-35 Degrees
Number of Heat Tubes per unit	16 Tubes
Cost per unit (sustainablefuture.biz)	$1,740 per module

- Total number of modules needed = (1,019.89 m^2)(1/2.77m per module) = **369 modules**
- Total Roof Area needed = (4.33 m^2 /module)(369) = 1,597.77 m^2 = **17,198.24 SF**
- Conservative Roof Area needed (accounts for spacing between modules) = (54.545 SF/module)(369) = **20,127.27 SF**
  - 54.545 SF/module based off a similar project done by Southland industries which utilized 18,000 SF for a 330 module array.
  - NOTE: will use conservative number for remainder of analysis

Solar Collector Analysis cont.

- Total Weight of proposed array = (369 mod.)(100 kg/mod.)(2.2046 kg/lb) = 81,349.74 lb of added load
- Total Cost of Collectors = (369 mod.)($1740/mod.) = $642,000
- Solar Collector Conclusions:
  - 369 Seido 1 – 16 AS collectors
  - 20,128 SF of space needed
  - 81,349.74 lb of additional loading
  - $642,000 for solar collectors

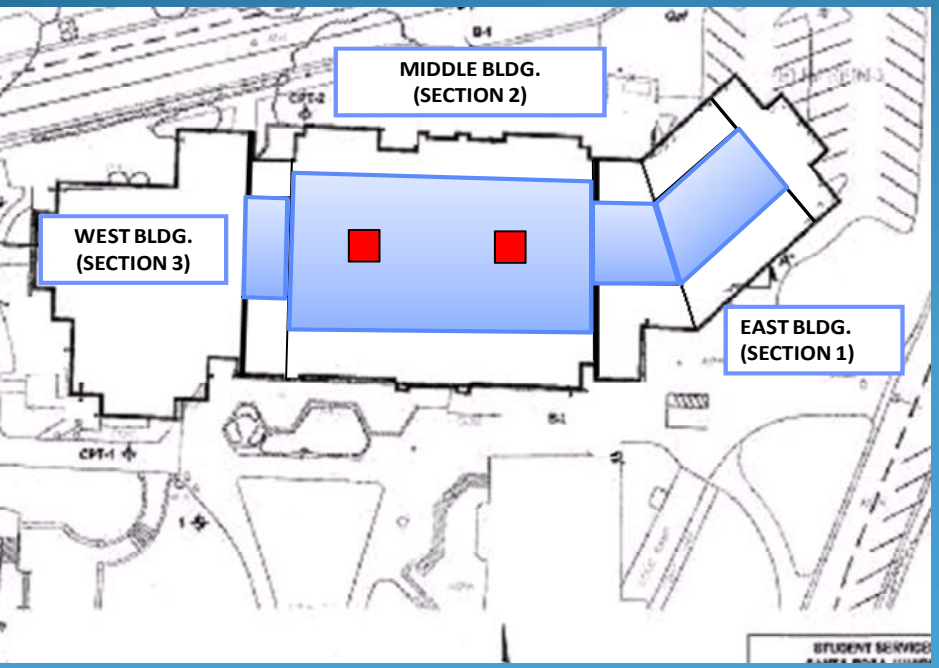
SUNDA
HIGHTECH SOLAR TECHNOLOGY

Architectural Breadth

- Student Center roof redesign to allow for solar array
- SRJC is very picky about architecture
- Neighboring Doyle Library has a similar architecture and utilizes a parapet wall to hide a rooftop solar array

Architectural Breadth cont.

- Spacious attic allows for roof to be lowered 8’
  - West end of the student center can not be altered due to vaulted ceiling in the café
  - East and Center sections can both be lowered 8’ with exception of two 9’ x 13’ elevator shafts that must remain



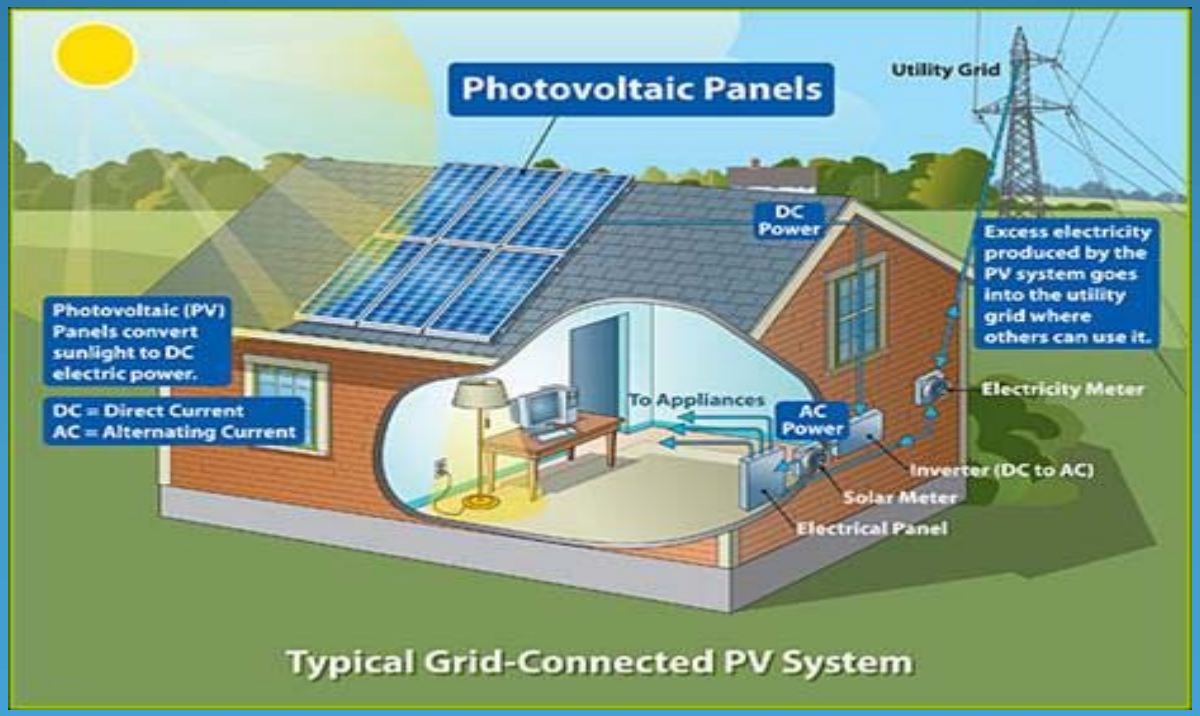
Architectural Breadth cont.

- Roof redesign analysis results:
  - East Building Section
    - 26 ft. width = 1248 SF of flat space
  - Center Building Section
    - 40 ft. width of flat space available (includes small 26 ft. wide section) = 5640 SF
    - Subtract area of two elevator shafts: 5640SF – 234SF = 5406 SF

  Total Area Available = 7,476 SF << 20,128 SF needed
- **Conclusion: Stay with geothermal system. Absorption chiller system can not match geothermal output because of lack of room for solar array.**

Electrical Breadth

- Since there is not enough room to meet 290 Ton heating/cooling load with an absorption chiller system will use available flat space (7,476 SF) for a solar array to generate electricity for the building instead.
- Environmental Benefits:
  - Renewable Energy Source
  - Zero Waste Emissions
  - No Negative Impacts in the Form of Land Use (incorporated into structure)



Electrical Breadth cont.

RECAP DATA

- Santa Rosa = 5.45 Solar Exposure
- Electricity Cost = $.139/kWh
- Annual Yield = 1,597 kWh/kW installed
- Available Space = 7,476 SF
- “Seido 1-16AS” solar collectors to be used
  - 54.54 SF each
  - 2.77m^2 of collection area each
  - $1,740 per module
  - 100 kg per module

NEW ANALYSIS DATA

(7476sf/54.54sf per module) = **137 Modules Available**

(137 modules)(2.77m^2/mod.) = **379.49m^2 of Collection Area**

(1597 kWh/m^2)(379.49m^2) = **606,045 .53 kWh Annually**

(606,045.53 kWh)($.139/kWh) = **$82,240.32 in electrical savings annually**

(137 mod.)($1740/mod) = **$238,380 initial cost of array**

Electrical Breadth cont.

New Analysis Data (cont.)

- ($238,380)(1 yr./$82,240.32) = 2.9 years to payback initial cost
- 3 Assumptions:
  - Payback period roughly = 3 years
  - Avg. lifetime of solar panel = 50 years
  - Most solar-electric systems installed today come with 20-25 year warranty

Attainable Lifetime Savings

Saving After 'X' Years	Total Savings
5 Year Savings	$164,480
10 Year Savings	$575,680
20 Year Savings	$1,398,080
25 Year Savings	$1,809,280
50 Year Savings	$3,865,280

Industry Issue Conclusions

- Redesign roof to allow for 7,476 SF of flat area that will be concealed from ground level by a parapet wall.
- Utilize available space for a 137 module solar array to generate up to 606,045 kWh of electricity and result in savings of $82,240 annually.
- Continue use of $1,500,000 geothermal loop to meet 290 Ton building heat/cooling demand.

Alternative Prefabrication Process

- **Problem:** The prefabrication process for concrete panels began far too early on for the project resulting in installation problems, delays, and excess spending.

- **Goal:** Eliminate delays and excess costs related to poor prefabrication process through the help of a design consultant in the design stage.

Original Prefabrication Process Analysis

- Precast bidders had to be pre-certified through the Precast/Pre-stressed Concrete Institute (PCI) plant certification program
- Precast contractor based out of Monteray, CA but plant is in Mexico
- Inaccurate pre-cast drawings made it impossible to meet minute tolerances.
- Critical Path Delays
- $200,000 in additional work

Design Consultant

Hiring of a precast subcontractor to act as a design consultant early on in the design stage to assist the process would have avoided many problems.

- Would require upfront cost
- Elimination of delays due to poorly detailed drawings
- Changes to drawings could have been made before time of bid
  - Work would be granted at bid prices opposed to change order prices

Design Consultant Impact

Time:

- Would prevent the beginning of what would end up being a 72 day critical path delay
- Would prevent 10 days of delays from rework not on the critical path
- No need for 72 day contract extension

Money:

- Would require an upfront cost.
- Would prevent $200,000 in rework costs from poorly fabricated members.
- Still best to prefabricate in Mexico where labor is about 1/10 the price it is in America
- Transportation costs are minimal compared to savings from cheap Mexican labor.

NOTE: Due to legal issues stemming from this issue on the SRJC Student Center project I was unable to obtain detailed information involving cost and schedule data.

Alternative Prefabrication Process Conclusions

- Based on limited information available, exact benefits are hard to determine.
- Hiring of Design Consultant early on in Design Stage of Construction would allow prefabrication errors to be caught before time of bid.
  - Would theoretically eliminate need for 72 day extension due to critical path delays and 10 extra days not on the critical path
  - Would require an upfront cost but nothing near the $200,000 lost due to rework
  - Labor is best performed in Mexico at a fraction of U.S. costs.
  - Additional transportation costs are nothing compared to labor savings.

- **NOTE: Newly planned Culinary Arts building for the SRJC which utilizes the same design team and architectural style as the student center project, was bid using a style nearly identical to the one I proposed with the hiring of a Design-Consultant**

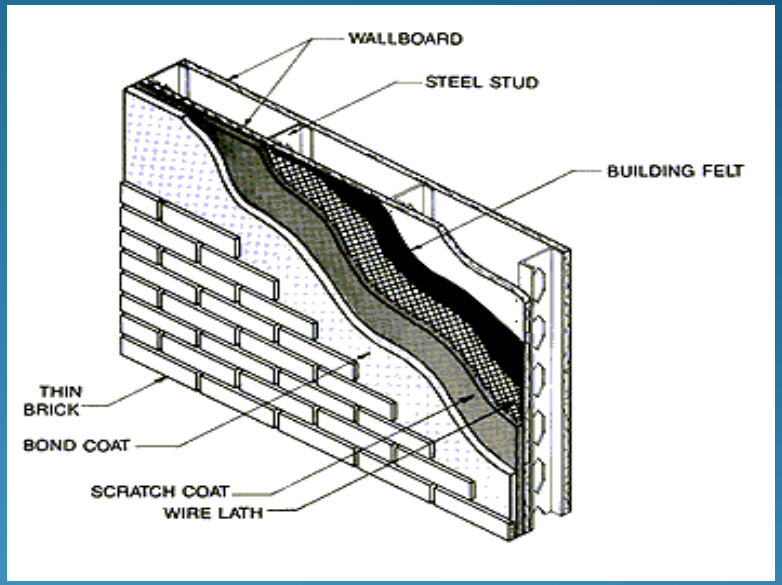
Alternative Façade Design

- **Problem:** Two types of support angles were used to support the brick façade of the Bertolini Student Center. Angles welded in the field were fairly simple, but prefabricated angles, welded in the shop, failed to meet tolerances resulting in delays and excess spending.
- **Goal:**
  - 1. Determine any benefits of using a thinner, lighter brick veneer opposed to full size bricks.
  - 2. Minimize delays and excess spending resulting from rework regarding prefabricated ledger angles.

Adhered vs. Full Size Brick

Adhered Brick

- Lighter than full size
- cheaper than full size brick
- “Prefabricated” look
- Would require rigid support system (complete re-design of structural frame)



Adhered vs. Full Size Brick

Full Size Brick

- Heavy
- Very expensive compared to thinner veneer
- Can be supported by steel angles that are welded to the structural steel frame of the student center

Façade Material Price Comparison

- Price of full size brick from RS MEANS = $16.50/SF
- Building Size = 66,646 SF

($16.50/SF)(66,646 SF) = $1,099,659

- Price of installed ½" veneer from BORAL BRICK INC. = $7.50/SF

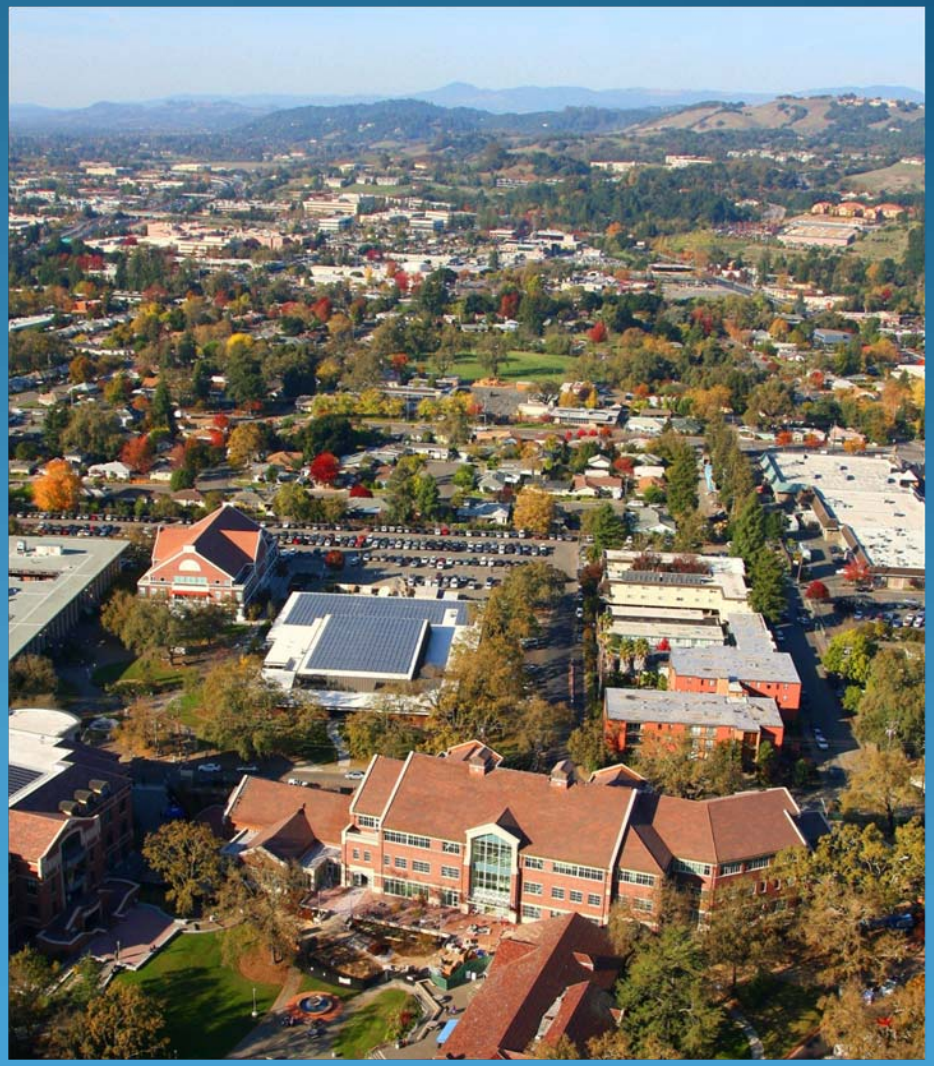
($7.50/SF)(66,646 SF) = $499,845

- Thin veneer savings = $1,099,659 - $499,845 = $599,814

SOURCE	MATERIAL	TOTAL COST
DESIGN TEAM ESTIMATE	Full Size Brick	$1,100,000
RS MEANS COSTWORKS	Full Size Brick	$1,099,659
BORAL BRICKS INC.	½" Adhered Brick Veneer	$499,845

Façade Material Conclusions

- Savings of $599,814 are misleading due to the need for a complete structural redesign.
- SRJC prides itself on its architecture and wants the “real deal”
- Many buildings on SRJC campus utilize full size brick.
- Donors want to see money going quality work
- Best to stick with full size brick



Shop Welding vs. Field Welding

Shop Welding Estimate

For a 20’ member…

- Shop labor rate = $55/hr
- Set up = 15 min.
- Welds = 40 welds @ 2 min. each = 80 min.
- Shop Equipment rate = $100/day

Shop Welding Cost= $14/ft

Shop Welding vs. Field Welding

Field Welding Estimate

For a 20’ member…

- Shop labor = $55/hr
- Field labor = $89/hr
- Load piece at shop = 5 min
- Unload piece in field = 5 min
- Stage at field location = 10 min
- Stage welder = 15 min
- Set in place, plumb, align = 20 min
- Field weld from man lift(move every 8 welds) = (2min/weld)+(5min/8weld) + 15 min for special inspector = 36 min
- Breakdown/cleanup = 3o min/day

- Shop labor = $9 per piece
- Field labor = $756 per piece
- Equipment = $133 per piece

Total: (9+756+133)/20’ piece = $45/ft

Field Welding Cost = $45/ft

Shop Welding vs. Field Welding

Results

1. ORIGINAL METHOD: Using both field welds and shop welds for ledger angles

	COST/FT	TOTAL FT	TOTAL COST	FT/DAY	TOTAL DAYS
FIELD WELDS	45	1,867	84,015	53	36
SHOP WELDS	54	1,179	63,720	64	19
REWORK DELAYS			50,000		30
GRAND TOTALS		3046 Ft.	$197,735		85 Days

2. PROPOSED METHOD: Use all field welds for ledger angles

	COST/FT	TOTAL FT	TOTAL COST	FT/DAY	TOTAL DAYS
ALL FIELD WELDS	45	3046	$137,070	53	58 Days

3. ATTAINABLE SAVINGS

	ORIGNAL METHOD	PROPOSED METHOD	SAVINGS
COST	$197,735	$137,070	$60,665
DURATION	85 Days	58 Days	27 Days

Alternative Façade Design Conclusions

- Stick with original decision to use full size bricks to meet SRJC's standard of excellence and to avoid a complete structural redesign
- Minimize costs by performing all welds in the field to ensure a high level of quality and no rework. (Attainable savings of $60,665)
- Accelerate schedule and eliminate delays by performing welds in the field to avoid installation errors associated with shop welds. (Attainable savings of 27 days)

Alternative Steel Erection Process

- **Problem:** The steel erection process got started late due critical path delays initiated by the poor prefabrication process of the concrete accent bands and fell even further behind because of the use of a single crane and installation crew. Delays resulted in the need for a 72 day contract extension and nearly $400,000 of excess spending.
- **Goal:** Minimize schedule delays and excess spending by investigating an alternative steel erection process.

Original Steel Erection Process

Steel Takeoff Numbers

Equipment	Member Description	Total
1 MOBILE CRANE	• 124 Columns (2 sections = 62 Each) • 762 Beams	886
1 FORKLIFT	• 35 Columns (1 section = west end) • 140 “X” Braces (at brace frames) • 159 Beams	334
	TOTAL MEMBERS:	**1220**

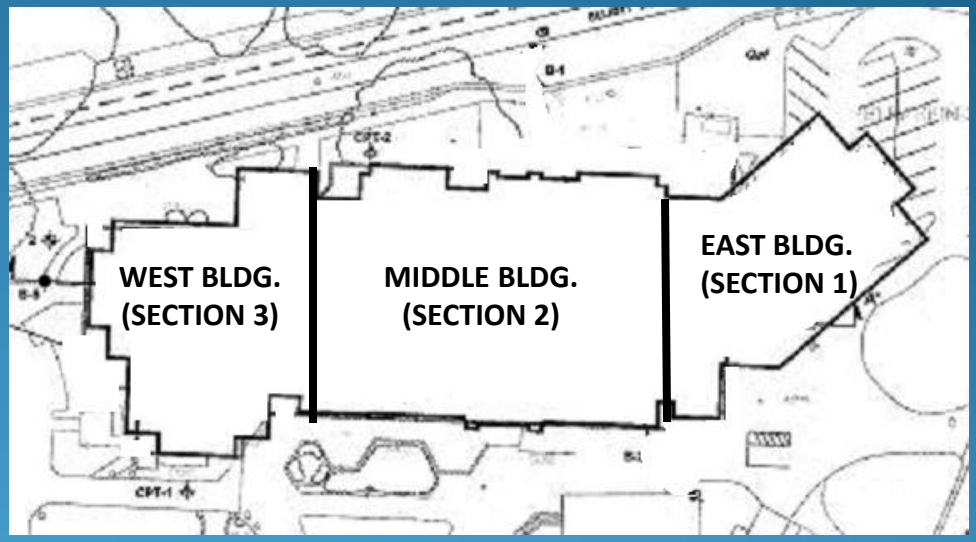
Breakdown of Steel Erection Crew

Responsibility	Number of Men	Rate
Staging steel	3	$89/hr
Helping to set each member	4	$89/hr
Following behind, completing bolting of members	9	$89/hr
TOTAL	**16 men at a rate of $89/hr**	

- Original Scheduled Duration = 24 weeks
- Actual Duration = 24 weeks + 12 week delay (72 day extension) = 36 weeks

Crane and Forklift Operation Dates

- Section 1 (East Section)
  - First Steel Set: 3-18-08
  - Crane Pulled: 4-16-08
- Section 2 (Center Section)
  - Crane Returned: 5-1-08
  - Crane Pulled for Good: 6-6-08
- Section 3 (West Section)
  - Forklift done setting main steel members: 7-15-08



•Steel sub spent about 8 months on site beginning in March 2008.
•The last 3 months were spent plumbing and welding.

NOTE: Forklift remained on site throughout entire erection process lifting misc. pieces.

Steel Erection Cost Breakdown Including Material, Crane, and Labor

- Steel Member Total Cost = $1,800,000
- Crane Rental = $15,000/wk (24 wk rental) = $360,000
  - 80 Ton Hydraulic Crane data from 2010 Current Construction Costs
- On Time Labor = 16 man crew for 24 wk. = $1,367,040
- Extra (Late) Labor = 9 man crew for 12 wk. = $384,480

- **Total Structural Costs without Delay = $3,527,040**
- **Total Structural Costs with 12 Week Extension = $3,911,520**

Alternative Erection Process Method Analysis

Total Members Set

- Crane = 124 Columns + 762 Beams = 886 Members
- Forklift = 35 Columns + 140 “X” Braces + 159 Beams = 334 Members
- 1220 Members Total

Approx. Time per Member

- 24 week schedule = 57,600 min
- (57,600min)/(1220 members) = 47.2 min per member

Alternative Erection Process Method Analysis

Original Erection Plan

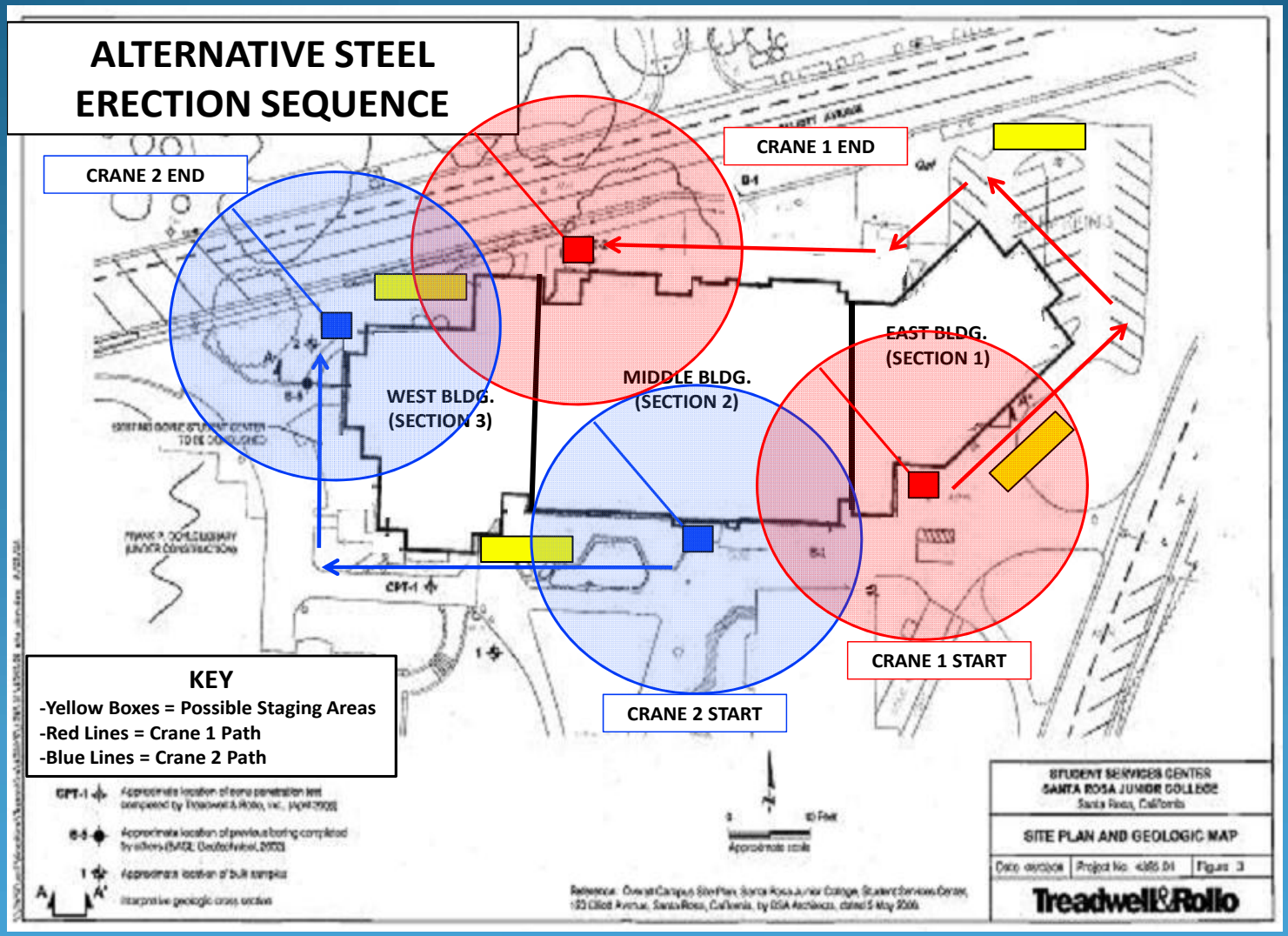
- 1 crane
- 1 crew
- Work moved from east to west
- 24 week schedule
- 12 week delay
- First 90% of steel erected very close to schedule
- $400,000 in excess spending

Alternative Erection Plan

- Utilize two cranes for erection process
- Utilize two crews for plumbing and welding
- Assume two cranes on site will not slow productivity due to congestion
- Two cranes will work simultaneously and continuously until the erection process is complete

Alternative Erection Process

Proposed Sequence



Alternative Erection Process Cost and Schedule Impacts

METHOD	TOTAL COST	TOTAL DURATION	TOTAL MONEY SAVED	TOTAL TIME SAVED
Original Method	$3,911,520	36 weeks	-	-
Alternative Method: Best Case	$3,527,040	12 weeks	**$384,000**	**24 weeks**
Alternative Method: Worst Case	$3,911,520	24 weeks	**$0**	**12 weeks**

- Original Method = 1 crane, 1 16-man crew
- Alt. Method Best Case = 2 cranes, 2 16-man crews, plumbing and welding done on time
- Alt. Method Worst Case = 2 cranes, 2 16-man crews, plumbing and welding take full 12 weeks extra

*Best and Worst Case scenarios are used to create a range of savings that could be attainable.

Alternative Steel Erection Process Conclusions

- Use two cranes and crews working continuously until the process is complete to attain time savings of up to 24 weeks
- Using two cranes and crews can result in cost savings of up to $384,000

Overall Analysis Conclusions

- The use of any or all of the proposed systems or methods have the potential to provide benefits in the form of cost savings and schedule reduction
- Providing a Design Consultant for the concrete prefab process could show savings of up to $200,000 and could reduce critical path delays
- Performing façade welds in the field can result in $60,665 in cost savings and 27 days of schedule reduction
- Using two cranes and crews for the steel erection process can result in savings of up to $384,000 and 24 weeks and could eliminate the need for a 72 day contract extension.

Acknowledgments

- I would like to thank my friends and family for their continued support throughout my college career
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Santa Rosa Junior College

QUESTIONS?