TITLE:
St Michaels Association for Special Education New Facility and Master Plan : Final Report

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St Michaels Association for Special Education
New Facility and Master Plan

Spring Term 2001 – Final Report
CAE-08

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Submitted to:
Professor James Mitchell and the Senior Design Faculty

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Abstract

St. Michael's Association for Special Education, located near Window Rock, AZ, is an institution that has been established for the schooling and therapy of approximately 100 mentally and physically challenged Navajo children and adults. The existing school buildings are located on a 20 acre site are structurally unsound, crowded and poorly equipped to handle the daily functions of the school.

FBM has outlined criteria by which the ideal solution to the problems at St. Michael's may be resolved. The selected design alternative is a single, one story, 70,600 square foot multipurpose building that addresses site, structural, electrical, HVAC, plumbing, fire protection, and other concerns of the students, faculty, and staff of St. Michael's.

The building is located on the previously developed portion of St. Michael's site. The site is regraded in order to accommodate the building materials and methods chosen and to add to the long term stability of the structure. Architectural features of the building fall in line with the client's preferences. Masonry bearing walls and steel KCS joists make up the superstructure of the building and are supported by continuous footings. Pilasters are employed for lateral support. A ground source heat pump is employed for HVAC. Solar power supplements 509,000 kWh per year of electricity supplied to the building.

Our design brings about a safe, efficient building that promotes a healing and nurturing school environment at a cost of about $7 million.

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Introduction

St. Michael's Association for special education (St. Michael's), located in the Navajo Nation near Window Rock, AZ, is a special education counterpart of St. Michael's School, located in the same town. St. Michael's is part of the original mission founded by Katherine Drexel, a recently canonized saint in the Roman Catholic Church and neice of Anthony J. Drexel, founder of Drexel University.

The special education school servesd the needs of approximately 87 children who are day students, about 12 of whom are infants. In addition, approximately 20 adults are enrolled in St. Michael's assisted living program. All of the students are Navajo Indians. About 140 total faculty and administrators are employed either full or part time by St. Michael's.

The 19 existing campus buildings cover approximately 32,000 sq. ft. of total building footprint. Several of these buildings show signs of structural damage due to apparent soil settlement. Most notably, the cafeteria has experienced settling of up to five in. across its floor span of about 85 ft. Many of the buildings are inefficient, exhibiting energy loads that are well above current design standards. Most of the buildings are cramped, having little space available for necessary daily activities. The disjointed buildings create ambulatory difficulties for the students.

St. Michael's does have the ability to improve its campus. If it provides state, federal, and Navajo Nation officials with preliminary engineering design plans for a new or augmented school facility, it will be able to apply for funding to do bring th eproject to completion.

FBM has considered many alternatives in designing each system of an ideal building for St. Michael's. Site development has been performed so that the placement of the building minimizes grading and drainage problems. The geotechnical design provides foundations that will support the building with minimal settlement. A masonry block retaining weall unifies grading on the site. The architectural design provides the amenities the faculty requested, while still conforming to the style of traditional Navajo architecture. The structural design provides adequate support for vertical as well as lateral loads, employing familiar, economical, and aesthetically pleasing building materials. Heating, ventilation, and air conditioning (HVAC) design employs a ground source heat pump system to handle building heating and cooling loads efficiently. The electrical system employs active solar energy systems to lessen electrical demand. The plumbing system provides potable water to all building fixtures.

Site Development

Proposed

FBM proposed to remedy many of St. Michael's settlement, space allocation, and stormwater problems through proper site development. The building was to be situated so that the students would experience a healthy, nurturing environment. The building location was to be on St. Michael's previously developed site. The building pad was to be elevated to maintain a 5% slope for a lateral distance of 15 ft. on all sides of the building to allow stormwater to move away. Parking was to be provided for all staff and administrators. Utilities were to be rerouted as necessary to connect with the new building.

Design Alternatives

A campus set up and a single building were considered for the new St. Michael's facility. A single building was selected based on the ability to provide for students needs, faculty preference, and cost. The building shape and orientation was chosen based on grading, geotechnical, architectural, and energy preferences noted in Appendices A, B, C, and F.

Final Design

The new building will be situated on the existing St. Michael's campus as shown on the site plan Appendix A. The existing cafeteria and "solar" classroom building will be removed to make room for the proposed building. The building will be oriented so that the main entrance faces east in accordance with Navajo custom. Principal hallways will be in the north/south direction, along an existing 1 to 2 percent slope, minimizing the amount of grading needed to provide a level building pad.

About 6500 CY of soil will be cut and deposited. No soil will be imported from off site. The cut/fill line will be initiated in the NW/SE orientation through the approximate middle of the building at an elevation of 6738 ft. Refer to Appendix for grading plan and associated calculations.

The natural landscape slope of between 4.1 and 5.5 percent to the east and west of the level building pad remains in order to provide a natural drainage path for stormwater. This natural slope dips to the south side of the building and will hold all stormwater for a minimum retention time of 5 hours. The fill soil is sloped 5% for a lateral distance of 15 ft. on all sides to allow runoff to be transported away from the building. Furthermore, four stormwater inlets are located 100 ft. apart on the east side of the building. Stormwater collected at these locations is transported beneath the building via 4 in. pipes and deposited on the building's west side. Refer to Appendix for stormwater calculations.

FBM will provide a 60 space parking lot located to the south of the proposed building. The lot will be gravel covered and underlain by a nonwoven geotextile. The lot is configured in a square "U" pattern and allows for two way travel in driveways. Overal parking lot dimensions are 140 ft. by 140 ft. The existing 3 percent slope in th earea of the proposed parking lot will be maintained to allow for adequate drainage. Refer to Appendix for parking lot details.

Water and sewer lines will be rerouted to the east and south of the proposed building. Refer to Appendix for site utility plan.

Geotechnical

Proposed

The proposed foundation system has been designed to support the superstructure of the building while minimizing settlement. A retaining wall has been designed to join existing and proposed grade lines.

Design Alternatives

A variety of shallow foundation types were considered for the proposed building, including spread footings, strip footings, and mat foundations. Strip footings were chosen as the best alternative based on the type of superstructure selected and loads expected.

Final Design

FBM presents a geotechnical design that will accommodate a 70,600 SF concrete masonry building. Continuous strip shallow footings with a base of 4 ft. wide located 4 ft. below the proposed building grade (6734 ft.) will be used to support the building's loads of about 3.5 kips per linear ft. This foundation will provide a factor of safety of 3.9 considering general shear failure. Refer to Appendix for bearing capacity calculations

Differential settlement is minimized, not exceeding one total in. at any location. This amount is reasonable to expect and acceptable for the size and type of the proposed building. Refer to Appendix for settlement calculations.

The concrete floor slab is 5 in. thick with steel wire mesh reinforcement. Construction joints are spaced every 40 ft. along the major axes of the building. The retaining wall will have a total length of 580 ft. around the proposed gymnasium to the north, east, and south, and will be a maximum of 15 ft. tall.The wall footing will be similar to the strip footing beneath the building, as detailed in the Appendix. It will be externally reinforced by a homogeneous bilateral geogrid with a tensile strength of no less than 10 kip/ft. An 18 in. permeable sand layer should be installed vertically behind the wall to carry water down to weep holes at the wall's base to alleviate hydrostatic pressure. Refer to Appendix for all foundation calculations.

A new boring location plan has been devised to determine soil properties in the exact location of the building. The plan may be viewed in Appendix.

The largest embankment on which a portion of the school will be built has been analyzed for slope stability. It has been determined that the slope is stable with the added surcharge weight of the building without external reinforcement such as geosynthetics. Refer to Appendix for calculations.

Architectural

Proposed

The architectural system proposed was one that could meet the varied and specific client needs. This design was to include a one story building composed of several wings. Each wing was to have a specific purpose (ie. Separate wings for classroom space and administration space). The overall building was estimated to be approximately 68,550 square feet. FBM also promised several features would be incorporated into each classroom space. An extensive list of rooms and areas that will be incorporated into the design. The client also requested to have the adult classrooms distinctly separate from the other classrooms, but still in the same building.

Design Alternatives

The first alternative explored was a three-wing design with a central entry space in the shape of a Hogan. One wing was for administrative needs, one wing was for classroom spaces and the gymnasium, and one wing was for the other spaces in the building (nurse's office, sound therapy, pottery, and macramé) as well as the cafeteria (see appendix C). A rough plan was then submitted for client review. With the client's comments FBM has arrived at a final design.

Final Design

The final design is similar to the initial design in that it still has three wings arranged around a central entry space in the shape of a Hogan. Some of the major changes include the addition of two classrooms, a teacher resource room/computer room, two small conference rooms and an employee lounge. These additions increase the size of the overall building to 70,600 square feet. The adult classrooms were moved to a less central space to allow for more privacy, and the nurse's office and sound therapy rooms were moved into the classroom wing. Refer to the final floor plan in appendix C.

The wall construction used for most of the building was and 8" CMU wall, 2" air space, 2" insulation, and ½" drywall with a steel stud backup.

<u>Structural</u>

Proposed

The structural system was proposed to withstand all lateral and gravity loads placed upon it. It was to have a maximum bay size of 25 feet, and a maximum deflection of L/240 in the steel members. The only major refinement to the design was an increase in the proposed bay size. The 25 feet that was proposed obviously overlooked the gymnasium and cafeteria. The bay size was also increased in the classrooms to provide a more usable space. The final spans of the gymnasium, cafeteria, kitchen, and classrooms were increased to 60 feet, 54 feet, 44 feet, and 35 feet, respectively.

Design Alternatives

The four main alternatives considered were steel, concrete, masonry wall with a precast concrete roof, and masonry wall with a steel joist roof. These systems were weighed against criteria such as availability of materials, availability of skilled workers, and ability to withstand deflections. A complete list of these criteria is provided in appendix D.

Final Design

After evaluating the criteria, a masonry bearing wall structure with a steel joist roof was selected. The system will resist a total wind load of 6.25 PSF pressure on the windward wall, 3.88 PSF suction on the leeward wall, and 5.425 PSF suction on the roof. These loads will be resisted using a system of pilasters and cross walls spaced at a maximum of 12 feet apart.

KCS joists will support the roof for all spans between 10 and 15 feet. They were chosen because of their high versatility. Since the exact locations of mechanical units and solar panels has not been determined yet. The KCS joists have a constant resistance to shear along the entire length of the span. Long span joists will be used for the longer span. W8x10 beams will carry shorter spans. Loads will be transferred to the joists by metal roof deck fastened to the top of them.

HVAC System

Proposed

Initial specifications called for interior design conditions of 78 ± 3 F db temperature during the summer and 72 ± 5 F db temperature in the winter, with 50 ± 10% relative humidity year round. It was also stated that 15-20 CFM/person of fresh outdoor air shall be supplied to the interior zones. The design criteria established for this project during the proposal phase are as follows:

- Energy efficiency
- Low costs (operational/maintenance as well as initial)
- Comfortable temperature levels
- Adequate moisture content of air
- Air cleanliness
- Adequate supply of fresh outdoor air
- Proper air distribution and circulation
- Minimal noise intrusion during system operation

Design Alternatives

Several alternatives were considered for this project, each possessing numerous advantages and disadvantages. The options receiving the most consideration were:

- Ground source heat pump system
- Thermal ice storage system
- Radiant heating and cooling panels
- Fan coil units
- Packaged rooftop air-conditioning units with baseboard heating

Thermal ice storage was eliminated from consideration once it was determined that there is not a large enough difference between electricity charges during peak demand periods versus off-peak demand periods. Radiant panel heating and cooling was eliminated because there have been many reports that the system has produced unreliable results in non-residential applications. Also, the lag-time (time for conditioned space to reach desired set-point temperature) involved with the system is high and a cause for concern. Fan coil units are highly maintenance intensive, can produce considerable noise intrusion in the conditioned space, and also require separate condensing units, resulting in additional maintenance requirements and added expense. The use of packaged rooftop units to satisfy the entire cooling load would be maintenance intensive and very expensive. For information on the systems listed above, refer to Appendix E, Section 'C'.

Final Design

The building loads were found to be 586.2 MBh for heating and 110 tons for cooling (see Appendix E, Section 'E'). The system selected for this project is a combination of two of the above-mentioned alternatives. Based on the design criteria, it has been determined that the use of ground source heat pumps in combination with packaged rooftop air-conditioning units is the best system to employ. This hybrid system offers many advantages, all of which are addressed in Appendix E of this report. The heat pump units will satisfy the heating and cooling requirements of each of the interior spaces within the building, including the classrooms, offices, and therapy rooms. 40 horizontal heat pumps shall be used, ranging from 1½ to 5 tons of cooling capacity. The packaged rooftop units will be utilized as makeup air units, which means that they will condition only the outdoor air supplied to the spaces, and not the total air supplied to each space. 10 makeup air units shall be utilized for the total building ventilation requirements. In terms of the ground coupled heat exchanger, the loop will consist of 120 bores drilled to a depth of 300 feet. The bores will be 2¾" in diameter, and the pipes will be 1" in diameter. The total flow rate through the ground loop will be 330 GPM, requiring a loop supply and return main sized at 8". The pumps used to circulate the brine solution will be two 40 HP pumps. Refer to Appendix E for more information on the system design.

An annual energy consumption calculation was preformed through Energy 10. By simulating our building with a normal HVAC system and ground source heat pump, it was found that 5.2 kBtu/ sqft. Refer to Appendix E for more information on annual energy consumption.

Electrical

Proposed

The overall objective of FBM Design was to provide adequate power for all building applications in an energy efficient design. The emergency power supply must provide adequate power in case of a power outage. The use of multiple control panels will power the separate applications. Daylighting will also be maximized in the building. Lastly, all design and construction will abide by the national electrical code.

Design Alternatives

The design alternatives that FBM has explored include wind and solar energy. Both alternatives were chosen because they are currently implemented in the region and are efficient in producing energy. The need to provide alternative means of producing energy is caused by a high energy bill. Currently, the entire campus is powered using electricity. Therefore, these alternatives will be implemented into the design to ease the demand from the utility grid.

Final Design

The decisions made by FBM provide the most feasible and efficient electrical system. The chosen electrical system must be able to support 509,000 kWh per year. The electrical system consists of a primary 13,200-volt service coming in from the utility grid provided by the Navajo Tribal Utility Authority (NTUA). The service will then pass through the meter. After passing through the meter, the voltage will be stepped down via a 277/480-volt transformer. Once the power has been stepped down it will pass through a substation, breaking off to mechanical panel and a 120/208 transformer. All power both 277/480 and 120/208 or both 3 phases services, only at the switchboard were 120/240-volt service is separated using one of the legs of the 120/208 does the power become single phase. The switchboard has a lighting, auxiliary, and emergency panel. The system integrates the use of solar power at the switchboard to power the single-phase auxiliary power needs. Also lowering the demand from the utility grid are self-contained exterior light units, which are solar powered Also incorporated is a generator for the emergency power. A complete system schematic is viewable in the back of Appendix F along with detailed descriptions of its individual components.

Plumbing

Proposed

The plumbing system has been designed to serve approximately 250 St. Michael's students, faculty, and staff. The potable water system will deliver hot and cold potable water to the cafeteria, student restrooms located in the classrooms, faculty restrooms, and the therapy pools. The wastewater system will convey wastewater from the sinks, toilets, and floor drains to the public sewer system, and ultimately deposited into a wastewater treatment facility. Another function of the plumbing system is stormwater drainage. Pitched roofs and roof drains have been implemented to facilitate this process.

Design Alternatives

Most design alternatives pertain to the hot water supply system. The hot water distribution system can use tankless water heaters or a boiler and storage tank combination to supply sufficient hot water at the fixture. Since FBM plans to use solar energy to generate hot water, there must be a storage tank to hold the hot water generated. This decision eliminates the use of tankless water heaters for primary hot water generation. FBM has decided to use a water heater to both supply the hot water and store it. The large capacity water heater serves a dual purpose as heater and storage tank and appears to be more economical than a separate boiler and storage tank combination.

Final Design

The final water distribution system will enter the building in a 3 inch supply main at a flow rate of 142 gallons per minute and a velocity of 7 feet per second. The water service will then split to 126 gallons of cold water and 72.5 gallons of hot water each minute. An explanation of why the hot and cold do not add to the total flow rate is included in Appendix G. A 600 gallon electric water heater will supply/store the hot water. The hot water loop will be circulated by ¾ horsepower in-line centrifugal pump. The sanitary system will include vents and traps to safely prevent waste gases from entering the building. The building sewer will be 4 inch diameter and slope of 1/4 inch per foot.

Constructibility

The phasing of construction for the proposed building has encountered a number of concerns. The process of construction is an inherently difficult issue from the nature of the project. St. Michael's is a year round institution; therefore, construction should be quick and quiet, occurring whenever possible at off peak times of the day so as not to disturb the daily work of the students and faculty at the school. All construction will ideally be completed in the summer when the student population is lowest.

The most important construction phasing issue is the cafeteria/kitchen area. Coincidentally, the existing and proposed kitchens lie almost exactly in the same place. Thus, the kitchen equipment should be moved out of the existing cafeteria into a temporary structure for most of the project. The proposed cafeteria/kitchen can be built first, although the grading for the whole site must be completed before the erection of any part of the permanent structure.

Economic Analysis

Three alternatives for the overall procedure of the project have been considered. Realizing that St. Michael's ideal building design, according to our building program outlined in the proposal stage of this project may exceed the estimated funding available, FBM could have cut back on the design so that the project would fall entirely within the expected funding value, design the structure in phases so that the whole project could be ultimately completed when more funding became available, or design the ideal building in the hope that more funding would become available sooner with a fallback on building in phases. FBM chose to design the ideal building.

After the design of all systems, FBM is under the projected ideal building budget. The building total is currently \$6.7 million, as opposed to the \$8.2 million estimated in the proposal. For a system breakdown of proposed budgets, refer to Appendix H.

Schedule

Research and preliminary system investigation took place beginning in June, 2000 and proceeded until December. System alternatives were evaluated and selected during January, 2001. Preliminary system design proceeded through February and March. Additions and alterations to the preliminary design have been performed through May. A detailed schedule is presented in Appendix I.

APPENDIX A: SITE DEVELOPMENT

Site Background

Saint Michael's Association for Special Education is located in the Navajo Nation, near Window Rock, AZ. At the southern tip of the Rocky Mountains, the landscape exhibits arid, desert like conditions.

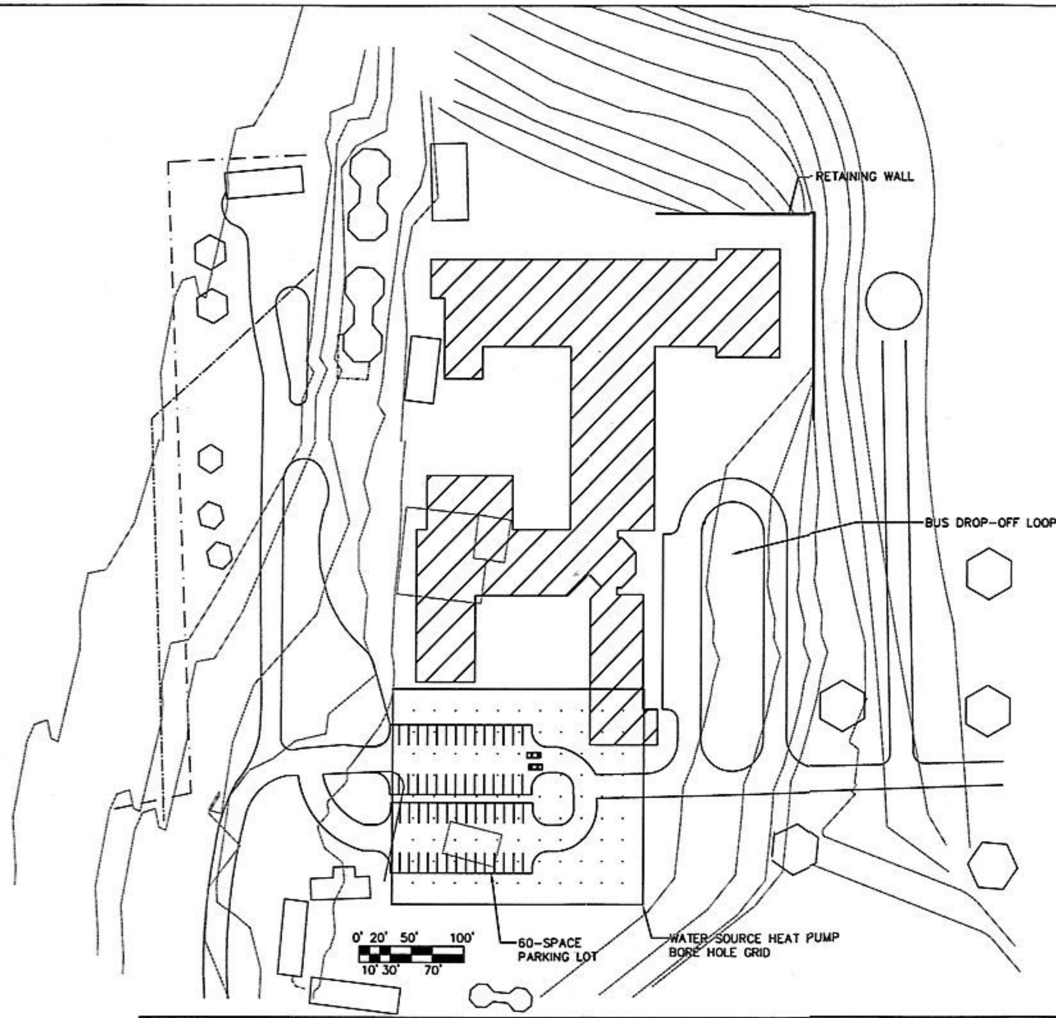
The site exhibits a moderate grade of about six percent sloping downward toward the southwest. Grading operations for existing buildings were performed on an individual basis, not in combination with other buildings. The elevation of the existing buildings is approximately 6700 to 6750 feet above sea level.

Several existing buildings on St. Michael's site lie directly in a natural drainage swale area where occasional seasonal rains drench the area and result in water infiltration into buildings and erode soils. This activity has indirectly caused structural damage to buildings by compromising the integrity of the building footprints.

Proposed Building Location

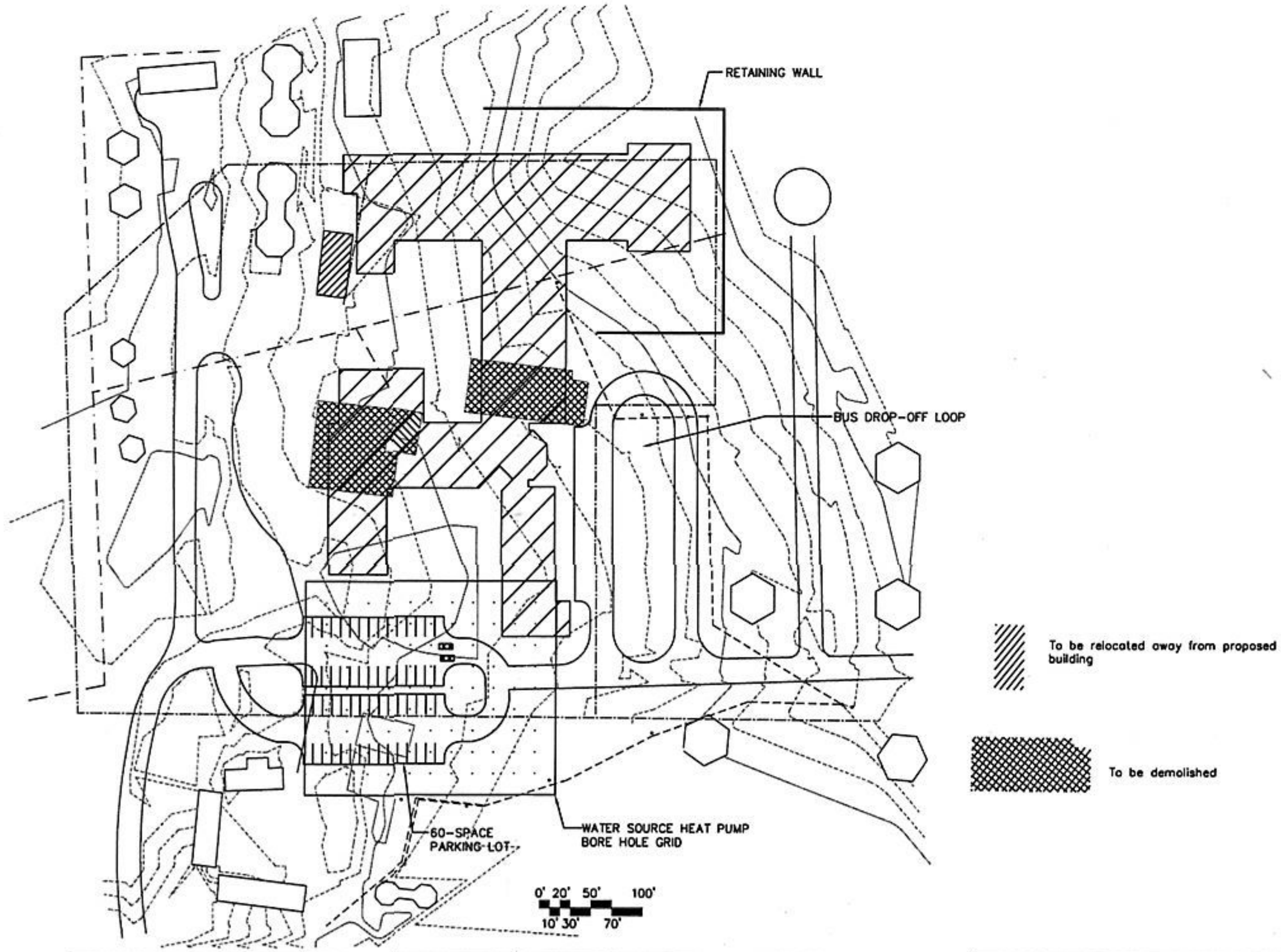
The proposed building will be situated on St. Michael's existing site as shown on the site plan. The existing cafeteria and "solar" classroom buildings, two of the most outdated and structurally deficient buildings, will be demolished in order to create space for the new building, as shown on the demoition plan on page A-2.2. The elevation of the proposed building is 6738 ft.

The chosen site has several advantages over other site alternatives, including the preservation of St. Michael's undeveloped space on campus, the ability of the site to sustain architectural preferences of the client, and the minimal amount of grading that will have to be performed, as detailed on page A-3.



F
B
M
Design

CLIENT	DRAWING TITLE	DRAWING NUMBER
ST MICHAELS ASSOCIATION FOR SPECIAL EDUCATION ST MICHAELS, AZ	PROPOSED SITE PLAN	C–2.2



FBM Design	CLIENT ST MICHAELS ASSOCIATION FOR SPECIAL EDUCATION ST MICHAELS, AZ	DRAWING TITLE PROPOSED BORING PLAN	DRAWING NUMBER C-2.3

Proposed Grading

The proposed grading for St. Michael's provides a level building pad at 6738 ft. Approximately 7,000 cubic yards of earth will be cut and redistributed on site as shown on the site plan.

Three ft. outside each exterior wall of the building, an 8 ft. wide sidewalk is provided. Immediately beyond the sidewalk, the ground slopes away from the building at a 5% slope for a lateral distance of 15 ft. Embankment fill areas beneath the building on its west side are typically 2 to 5 ft. However, the maximum embankment height is 9 ft, located beneath theproposed cafeteria area.each embankment employs a 4H to 1V slope to join the existing and proposed grades.

An embankment stability analysis has been performed for the highest embankment under the greatest load (the embankment beneath the cafeteria). The results have shown that the slope is stable and external reinforcement of the slope by geosynthetics or similar materials is not necessary. Calculations can be found in Appendix B.

Approximately 7000 cu. yds. on soil will be extracted and redistributed as shown in the proposed site plan. this soil will be primarily clayey sand with a unit weight of about 109 pcf. Using a 3 cu. yd. backhoe, 250 cu yds. per hour can be excavated at a cost of about $1 per cu. yd. Using three 20 cu. yd. dump trucks, 7.5 loads per hour can be transported to the appropriate fill area at a cost of about $2.30 per cu.yd. A spreader will be used to level the building pad at a cost of about $1.10 per cu. yd. Using these rates, the regrading process is estimated to take about two weeks and cost a total of about $60,000.

Stormwater

The proposed stormwater drainage plan is designed to eliminate the drainage difficulties encountered on the eisting site, including the alleviation of large quantities of standing water that are present after storms and other drainage problems that are associated with building settlement as noted in Appendix B.

The level building pad is implemented at 6738 ft. The natural landscape slopes of about 4.2% to the southeast, 5.5% to the west and 6.0% to the northeast will remain in order to provide a natural drainage path around the proposed building. In addition, 4 stormwater inlets located along the east side of the building spaced about 75 ft. on center as shown on the site plan, will be implemented. These inlets will deliver stormwater to 4 in. diameter PVC pipes sloped at 8% that will transport water under the building to the west side.

All soil immediately outside of the sidewalk area around the building will be sloped 5% for a lateral distance of 15ft. to allow rainfall and roof runoff to flow away from the building as per the recommendation of Agra Inc., of Farmington, NM. On the west side of the building, a slope of 15% will be implemented as shown on the site plan to connect existing and proposed grade lines.

A 25 yr. storm for the geographic location of St. Michael's is 2 in. over 24 hrs (National Weather Serice data). Peak runoff has been determined using the rational method. Using C = 3.0 and a rainfall intensity of 1" per hour, peak runoff has been determined to be 6,600 cu ft. The capacity of the existing swale to the south and west of the proposed building exceeds this amount, providing a 25 yr. storm a retention time of 4.4 hrs, far above the design standard of 10 min. See the following page for stormwater calculations.

$Q_1 = kCiA = 1.008(0.3)(0.083)(18.5) = 0.47 \text{ CFS}$

$Q_2 = kC_i A = 1.008(0.9)(0.083)(1.5) = 0.11 \text{ CFS}$

$Q_{peak} = 0.58 \text{ CFS}$

$t_c = t_o = \frac{107 n L^{0.33}}{S^{0.2}} = \frac{107(0.1)(875)}{0.05^{0.2}} = 17{,}045 \text{ sec} = \boxed{4.37 \text{ hrs}}$

>> 10 min

$t_p = t_{lag} = \frac{t_c}{0.6} = 7.88 \text{ hrs}$

$T_b = (t_p - t_c) 2 = 6.31 \text{ hrs}$

$Q_{RO_{total}} = \frac{Q_{peak} T_b}{2} = \boxed{6600 \text{ CF}}$

Drainage to inlets:

$Q = CiA = (3)(0.083)(5) = 1.245 \text{ CFS}$

$\frac{1.245}{4} = 0.311 \text{ CFS/inlet}$

$FS = \frac{q_{allow}}{q_{rqd}} = \frac{0.311}{0.21} = \boxed{1.5}$

$q_{rqd} = 0.311$

for 4" pipe, $q_{ult} = 0.07$

$q_{allow} = \pi RF q_{ult} = 3.0(0.07) = 0.21$

Drainage to weep holes in retaining wall:

$Q = CiA = 3(0.083)(2) < 1.245$

Since 1.245 > q_{rqd} with same area, $FS > \boxed{1.5}$

Parking

A square, 60 space parking lot with a U-shaped driveway located to the south of the proposed building is provided. the driveway of the parking lot is connected to the main access raod to the school at the east and west ends as shown in the site plan. Overall dimensions will be 140 ft. per side. Individual spaces will be 19 ft. long and 9 ft. wide. Four handicapped spaces, 19 ft. long and 13 ft. wide are also provided in accordance with ADA. Four rows of cars will be separated by two driveways as shown on the site plan. Driveways will be 22 ft. wide and will be made of the same base course material as the parking lot. Driveways will be orthogonal to the parking space orientation to allow for easy entry or exits from spaces when cars are traveling in either direction of the driveways.

The lot will be gravel underlain by a nonwoven geotextile applicable for the separation of soil and gravel particles. The existing grade will be maintained at about 5.1% to allow for adequate drainage as shown on the site plan.

Site Utilities

Potable water, sewer, and electrical utility lines currently exist as shown in the existing site plan. All utilities are provided by the Navaho Tribal Utility Authority. Utilities will continue to be supplied to the proposed building from this company.

Water and wastewater lines will be relocated around the proposed building as shown in the proposed utility plan. Both lines will be rerouted to the southand west of the building. The natural existing slope of about .5% will provide adequate gravity flow through the pipe. The electrical lines will be connected to the proposed building after construction.

A groundwater heat pump well grid will be drilled at the south of the proposed building area as shown on the site plan. It should be noted that the well grid is shown here only in order to give an idea of the relative size of the grid. The grid need not be laid out in a geometric square pattern as shown. For ease of maintenance, it would be better to not locate the grid directly under any part of the building. The exact location of the grid should be determined with regards to construction scheduling and landscape architecture, which are outside the scope of this project.

Alternate Site Consideration

At the presentation of the progress report to St, Michael's on March 20, 2001, an alternate site plan was discussed. The possibility was raised by H. John Sivroy, a private managerial consultant for St. Michael's, of removing the proposed retaining wall from the east side of the building, relocating it to the west side, and filling the entire area in the middle. Due to the magnitude of the task of determining the feasibility of this solution, FBM has decided not to explore the possibility during the completion of this Senior Design Project.

A number of issues would need to be investigated if this design was to move forward. First, the availability of the enormous volume of fill required to grade up the approximately four acre building area would have to be noted. This fill would have to be well graded non-plastic soil similar to that of the in-situ first 15 ft. of soil at St. Michael's in order for the proposed foundations to perform satisfactorily. The cost effectiveness of moving and adequately placing about 100,000 cu. yds. of such fill would then have to be evaluated.

The west side retaining wall would then have to be evaluated. Instead of a 14 ft. high retaining wall at the east side, the west side wall would be about 30 ft. high and would have to negotiate the added lateral earth pressure induced by the weight of the building behind it.

Because of the magnitude of the analysis needed to determine the feasibility of this task, and because of many obvious potential pitfalls including but not limited to the ones noted above, this alternative is rescinded for consideration of the St. Michael's board.

APPENDIX B: GEOTECHNICAL

Soil Survey

This soil survey is based on a geotechnical study performed in 1997 by Agra Earth and Environmental Services, Inc., Farmington, NM. Nine test borings were performed inside and around the existing cafeteria building. Refer to page B-8 for the boring location plan.

The existing soil at St. Michael's exhibits four major strata at the following average depths:

- Fill, silty sand (SM), from average depths of 0 to 2 ft.,
- Clayey sand (SC), from average depths of 2 to 7.5 ft.
- Silty clay (CL), from average depths of 7.5 to 18.5 ft.
- Auger refusal occurs at an average depth of 18.5 ft. Spoon refusal occurs at an average depth of 20 ft.

No groundwater was found in any of the boring locations, although samples were generally moist.

Soil Analysis

Soil in stratum one (Fill) is comparable to the clayey sand layer beneath it in color and density. It is probable that the fill was taken from elsewhere on the 20 acre St. Michael's campus and compacted in place on the existing cafeteria building pad.

Soil in strata two and three (SC and CL, respectively) are normally consolidated residuals. These soils exhibit low densities averaging 104 pcf, medium plasticities with plasticity indexes averaging 20, and high compressibilities, averaging about 7 percent compression in-situ.

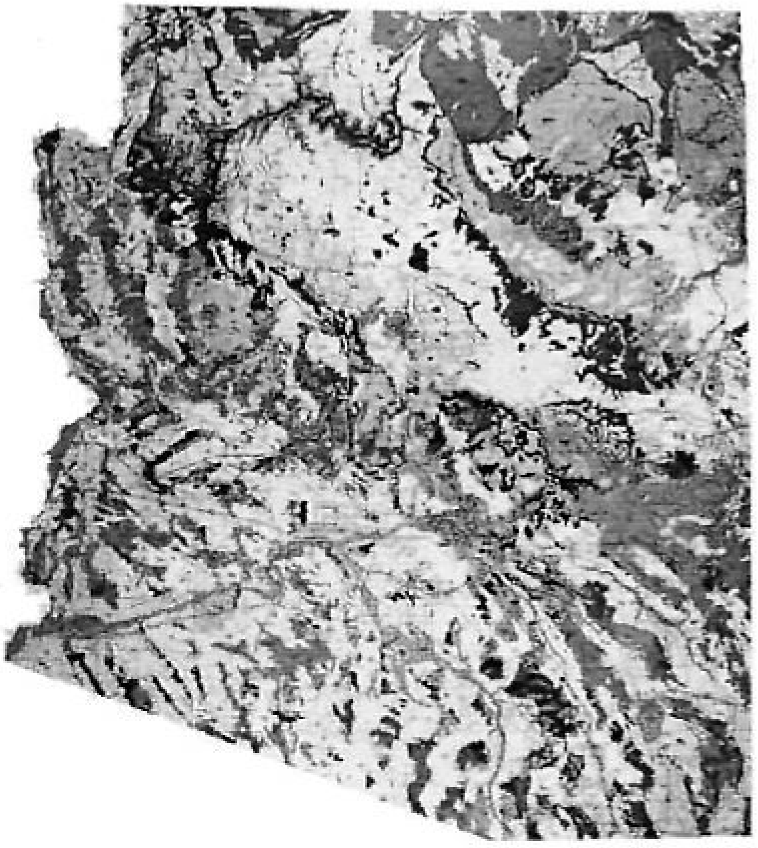
As a result, soils typically exhibit low ultimate bearing capacities at depths where foundations are located (0 to 2 ft. below the surface), averaging one tsf. Furthermore, stratum two exhibits a high primary consolidation number, although it is impossible to precisely calculate without building surcharge load data, which is unavailable.

Spoon refusal occurred at an average depth of 20 ft. No rock core samples were taken. From the geologic history of the area, it can be concluded that the area is underlain by moderately to slightly weathered sandstone.

Geologic Survey and Conclusions

Arizona has a complex geologic history that spans 1.8 billion years and resulted in the formation of three geologic provinces: the Colorado Plateau, Transition Zone, and Basin and Range Province. Our site lies in the Colorado Plateau in northern Arizona. It is a region of broad plateaus and mesas composed of picturesque sedimentary rocks deposited during the Paleozoic and Mesozoic Eras (570 to 245 million years ago). On the Geologic Map of Arizona, the Colorado Plateau includes the large region shown in light shades extending from the northwest corner south and east to the middle of the eastern boundary of the state. The Plateau is incised by deep canyons, such as the Canyon de Chelly, which are illustrated on the map by the purple and brown colors that represent deeper rocks exposed in the canyons.

It may be noted from the geologic history of the region and the fact that no buildings were built on St. Michael's site before the school's campus that soils on site are normally consolidated.



Geotechnical Conclusions

Based on observed structural conditions in St. Michael's existing buildings, the soil survey provided by Agra Inc., and accompanying soil lab testing and analysis, it can be concluded that several buildings on campus, especially the cafeteria have experienced building settlement. Most of this settlement has probably occurred as primary consolidation in the stratum three, the silty clay layer from average depths of 7.5 to 18.5 ft.

It can also be concluded that stormwater infiltration into the building area has exacerbated the consolidation settlement. Secondary consolidation may be a result of dissipation in pore water pressure below some buildings, which may result in further overall settlement.

It is estimated that parts of the cafeteria building may have settled between 0.5 and 1.0 in. since the current geotechnical survey being used for analysis was performed in 1997. Furthermore, it is likely that building settlement will continue in the if actions are not taken to remediate the situation.

The proposed geotechnical design considers low ultimate bearing capacities of approximately 1.0 tsf. In addition, differential building settlement should be minimized, with no part of the building experiencing more settlement than 1 in. total.

Proposed Foundation

The proposed foundation for the new St. Michael's Facility consists of continuous wall footings located under each load bearing concrete masonry wall (four along each axis of the building). The footings will be cast in place concrete four ft. wide and one ft. thick, with its bottom surface at Elevation 6733 ft., four ft. below the proposed grade of the building.

The footings will be used to support the building's vertical loads of 3.5 kips per linear ft, supplying a factor of safety of 3.9 against general shear failure. Furthermore, total building settlement of more than 1.0 in. will be prevented. Refer to the following sheets for calculations.

⇒ $\phi \cong 14°$

$\gamma = 104.5$ pcf

$c_d = 363.5$ pcf

$\phi = \tan^{-1}\left[\dfrac{N_F}{12.2 + 20.3\left(\frac{\sigma_v'}{p_o}\right)}\right]^{0.34} \cong 14°$

∴ $N_c' = 9.31$

$N_q' = 2.55$

$N_\gamma' = 0.48$

$q_u = \frac{2}{3} c N_c' + q_f N_q' + \frac{1}{2} \gamma B N_\gamma'$ (Terzaghi - modified)

assuming $D_f = 4$ ft, $B = 4$ ft

$= 3422$ lb/ft²

$q_{all} = \dfrac{3500 \text{ lb/ft}}{B} = \dfrac{3500}{4} = \boxed{875 \text{ lb/ft}^2}$

$FS = \dfrac{q_u}{q_{all}} = \dfrac{3422}{875} = \boxed{3.9}$ (for general shear failure)

Elastic Settlement in 15 ft. Clay Layer

$H = 15$ ft (any value)

$E_c = \dfrac{2.5 \text{ Kip/ft}}{\frac{\Delta H}{H}} = \dfrac{2500}{\left(\frac{5 \text{ in}}{15 \text{ ft}}\right)} = 7500 \text{ psi} = 90{,}000 \text{ psf}$ (existing condition)

$\mu_c = 0.4$

$S_e = \dfrac{A_1 A_2 q_o B}{E_s} = \dfrac{0.75\,(0.96)\left(\frac{3500}{4}\right)4}{90{,}000} = 0.467$ inches

$= S_e \cong \boxed{0.5 \text{ inches}}$

Secondary Settlement in 15 ft. clay layer

$C_c = 0.009(LL - 10) = 0.2565$

$\gamma_d = \frac{\gamma}{1+w_c} = \frac{104.5}{1+0.113} = 93.9 \text{ lb/ft}^3$

$\gamma_{sat} = \left(1 - \frac{1}{G_s}\right)\gamma_d + \gamma_w = 122.2 \text{ lb/ft}^3$

$\gamma_{sat} = \frac{(G_s + e_o)\gamma_w}{1+e_o}$

$\Rightarrow e_o = 0.825$

$G_s = 2.75$
$P_o = 1579 \text{ lb/ft}^2$
$LL = 38.5$
$w_{avg} = 11.3\%$
$H_c = 15 \text{ ft}$

$m_1 = L/B$	z	$z/\frac{B}{2} = n_1$	I_c	$\Delta P = q_o I_c$ (lb/ft²)
100	7.5	3.75	0.176	154
100	$7.5 + \frac{15}{2} = 15.0$	7.5	0.086	75.25
100	7.5+15=22.5	11.25	0.058	50.75

$= \gamma_1 H_1 + \frac{1}{2}\gamma_2 H_2$

$= 106(7.5) + \frac{1}{2}(104.5)(15) = 1579 \text{ lb/ft}^2$

$\Delta P_{avg} = \frac{1}{6}(\Delta P_t + 4\Delta P_m + \Delta P_b)$

$= \frac{1}{6}(154 + 4(75.25) + 50.75)$

$= 84.3 \text{ lb/ft}^2$

$S_c = \frac{C_c H_c}{1+e_o} \log\left(\frac{P_o + \Delta P_{avg}}{P_o}\right)$

$= \frac{0.2565(15)}{1+0.825} \log\left(\frac{1579 + 84.3}{1579}\right)$

$= 0.57'' \approx$ **0.6 inches**

$S_{TOTAL} = S_e + S_c = 0.5 + 0.6$

$=$ **1.1 inches**

FBM Engineers
Geotecnical Calculations

3/2/01

Concrete Floor Slab

$K \cong 225$ lb/cu in.

FS = 1.7

$E_c = 4000$ KSI

$\nu = 0.15$

$q_{ult} = \frac{14\ K/ft}{80} = 0.175$ KSF

Say, Slab thickness (t) = 6 in.

⇒ flexural strength = 1320 psi

and $f'_c = \frac{1}{2}(flex) = 660$ psi

Aisle width = $\frac{\text{Slab Width}}{2} = 40'$

$q_{allow} = 8.25$ KSF >> q_{ult}

⇒ use **t = 5"** just to have a substantial base (FS >> 1.7)

Reinforcement:

$$A_s = \frac{FLW}{2 f_s} = \frac{\tan 14^\circ (40)(12.5 \times 5)}{2(30{,}000)} = \boxed{0.011\ in^2/ft}$$

⇒ use **6"** spacing of wire mesh (steel) diameter = **0.2"**

2" below finished surface

⇒ construction joints spaced at 40 ft.

Embankment Stability

gamma (pcf) 104.5
phi (deg) 14
c (psf) = 365

(No geosynthetic reinforcement)

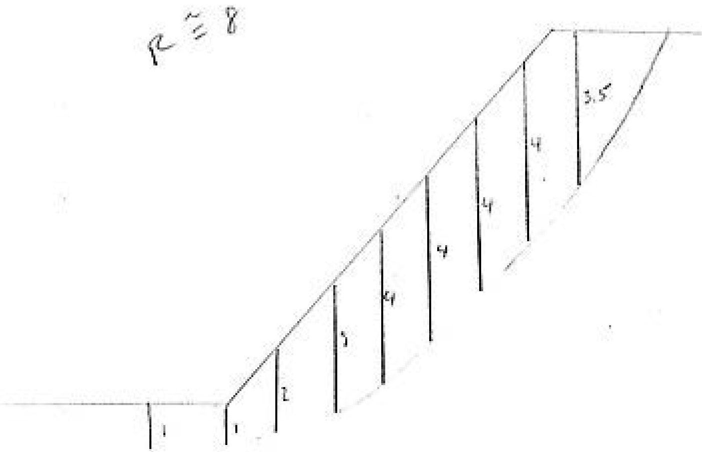
slice (n)	width of slice (ft)	length of slice	Area(ft^2)	Weight (lbs)	Theta (d	Theta (rads)	Ni (kN.m)
1	10	1	10	1045	-25	-0.4361111	947
2	10	1	10	1045	-22	-0.3837778	969
3	10	1.5	15	1567.5	-20	-0.3488889	1473
4	10	2.5	27.5	2873.75	-12	-0.2093333	2811
5	10	3.5	37.5	3918.75	-9	-0.157	3871
6	10	4	42.5	4441.25	0	0	4441
7	10	4	42.5	4441.25	10	0.17444444	4374
8	10	4	40	4180	15	0.26166667	4038
9	10	4	40	4180	20	0.34888889	3928
10	10	3.5	35	3657.5	25	0.43611111	3315
		sum	300.00	31350			30167

	[Ni*tan(phi)+c*li] (ft-lbs)	[Wi*sin(thetai)] (ft-lbs)	[W (surcharge)*sin (thetai)] (lbs)
	266.0	9.2	30.9796
	271.5	-954.0	-3195.3
	397.1	841.1	1878.01
	730.5	-1184.3	-1442.4
	994.5	0.0	0
	1136.7	-2416.1	-1904.1
	1119.9	2888.1	2276.01
	1036.2	3816.1	3195.31
	1008.9	-553.2	-463.23
	7547.5	0.0	0
sum	14508.9	2446.8	375.273

Wi*sin(thetai)*R
=> 19574.49862

yi (ft)		Ti*yi (lb-ft)
	0	0
	0	0
	0	0
	0	0
	0	0
	0	0
sum		0

⇒ Trial at critical section
(maximum slope height, surcharge)



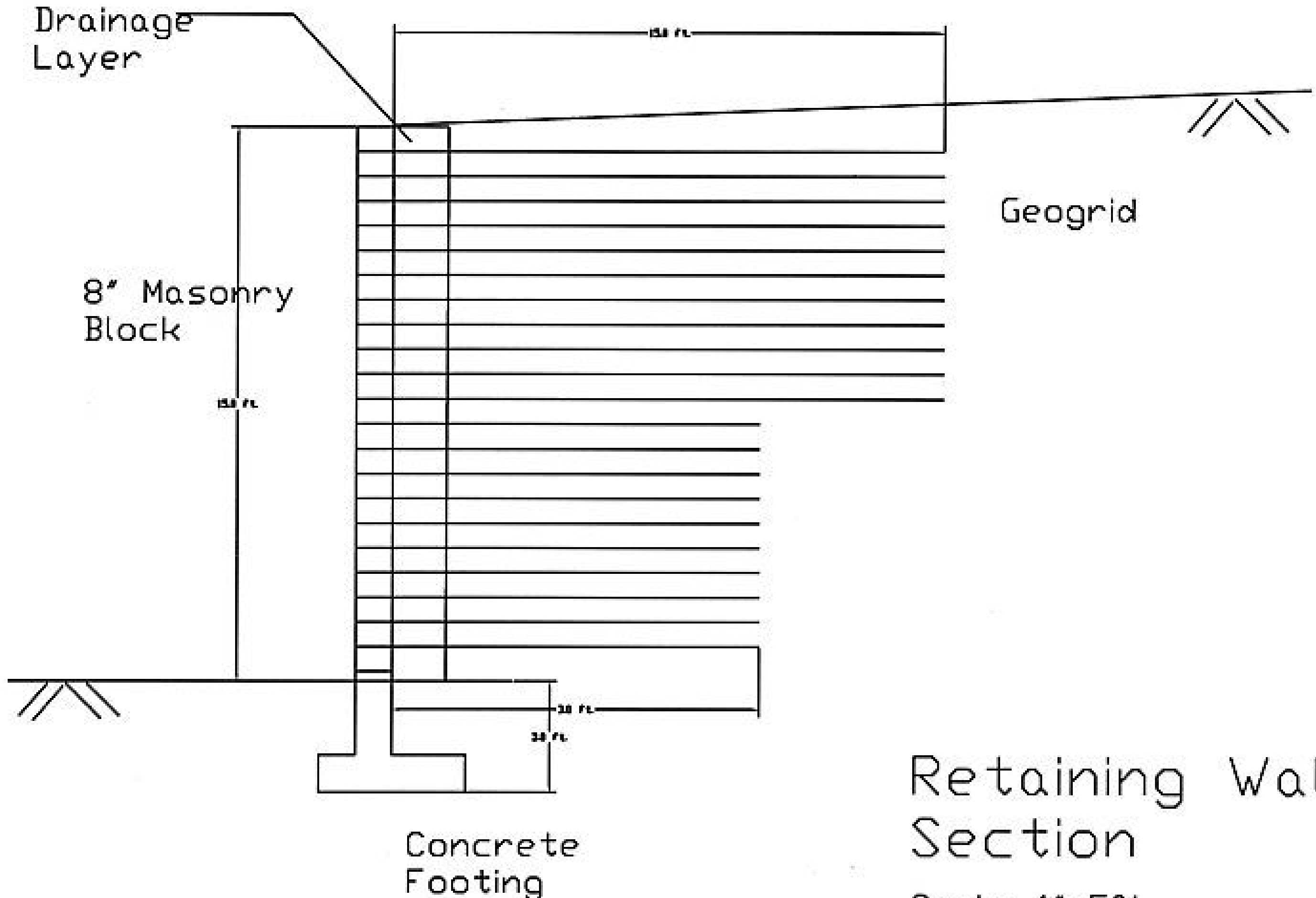
$$FS = \frac{F_{Resisting}}{F_{Driving}} = \frac{\sum_{i=1}^{n} (N_i \tan\phi + c\,\Delta l_i) R + \sum_{i=1}^{m} T_i y_i}{\sum_{i=1}^{n} (W_i \sin\theta_i) R + W_{surcharge} \sin\theta_i}$$

$$= \frac{14508.9 + 0}{2446.8 + 375.3} = \boxed{5.1}$$

⇒ no external reinforcement required

Proposed Retaining Wall

The proposed retaining wall rises a maximum of 14 ft. above the proposed grade of Elevation 6738 ft. It will be constructed of 8 in. concrete masonry block, with a 3 ft. deep concrete footing, as shown in the following section. It will be reinforced with 10 and 15 ft. lengths of geogrid having a machine direction ultimate tensile strength of at least 10 kip/ft.. An 18 in. sand layer having a transmissivity of at least 0.01 cm/sec will be installed vertically behind the wall. Drainage will be through weep holes 4 sq. in. and spaced every 10 ft. along the base of the wall at a height of 1 ft. above the finished ground surface. Refer to the following sheets for diagrams and calculations.



Retaining Wall Section

Scale: 1"=50'

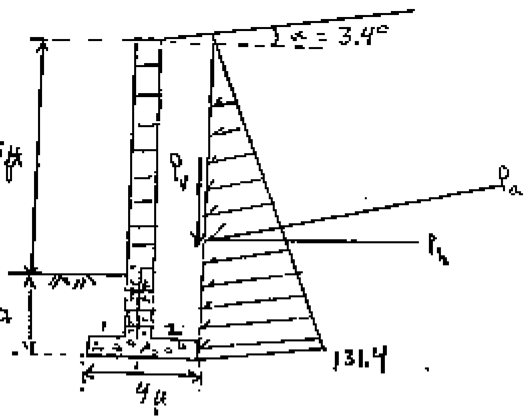
<u>Segmented Retaining Wall</u>

$\phi \cong 14°$ (Foot in clay, 15 ft below existing grade)

$K_a = \tan^2(45 - \phi/2) = 0.07$

$\gamma = 104.5$ lb/ft³
$c_d = 363.5$ lb/ft³
$wt_{block} \cong 15$ lb.

z	$\sigma_h' = K_a \gamma z \cos\alpha$ (lb/ft²)
0	0
2	14.6
4	29.2
6	43.8
8	58.4
10	73.0
12	87.6
14	102.2
16	116.8
18	131.4



$P_h = \boxed{1180 \text{ lb/ft}}$

$\Sigma V = W_{t \text{ on heel}} + W_{wall} + W_{toe}$
$= 104.5(1)(17) + 15(22.5) + 104.5(1)(2)$
$= 4100$ lb

$N_c = 10.37$
$N_q = 3.59$
$N_\gamma = 2.29$

- Passive pressure is ignored for conservatism

<u>Bearing Capacity</u>

$e = \frac{B}{2} - L_{toe} = \frac{4}{2} - 1 = 1'$

$B' = B - 2e = 4 - 2 = 2'$

$q = \gamma D = 104.5(4) = 418$ lb/ft²

$F_{cD} = 1 + 0.4\frac{D}{B'} = 1 + 0.4\left(\frac{4}{2}\right) = 1.8$

$F_{qD} = 1 + 2\tan\phi\,(1 - \sin\phi)^2 \frac{D}{B'} = 1.573$

$F_{\gamma D} = 1$

$F_{ci} = F_{qi} = \left(1 - \frac{\psi}{90}\right)^2 = 0.491$

$F_{\gamma i} = \left(1 - \frac{\psi}{\phi}\right)^2 = 0.85$

$\psi = \tan^{-1}\left(\frac{P_a \cos\alpha}{\Sigma V}\right) = 26.9°$

$q_{ult} = c_d N_c F_{cD} F_{ci} + q N_q F_{qd} F_{qi} + \frac{1}{2}\gamma B' N_\gamma F_{\gamma D} F_{\gamma i}$
$= 363.5(10.37)(1.8)(0.491) + 418(3.59)(1.573)(0.491)$
$+ \frac{1}{2}(104.5)(2)(2.29)(1)(0.85)$
$= \boxed{4694 \text{ lb/ft}^2}$

$q_{max} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right) = \frac{2324}{3}\left(1 + \frac{6(0.5)}{4}\right) = \boxed{1185 \text{ lb/ft}^2}$

$FS = \frac{q_{ult}}{q_{max}} = \frac{4694}{1185} \cong \boxed{4.0}$

Retaining Wall - Internal Stability

$T_{des} = \frac{T_{alt}}{T_{allow}} = \frac{10 \text{ Kip/ft}}{3.8} = 2.6 \text{ Kip/ft}$

C_r = cover ratio = 0.8

$T_{allow} = \frac{T_{ult}}{\pi RF} = \frac{10}{2.62} = 3.8 \text{ k/ft}$

$\sigma_h = \gamma z K_a = 104.5(0.07)z$

(1) vertical spacing

$T_{des} = \frac{S_v \sigma_h}{C_r} \Rightarrow S_v = \frac{0.8(2.6)}{7.32 z}$

Max depth for $S_v = 3$ ft :

$3(7.32)z = 0.8(2.6)$

$z = 0.094$ ft (not applicable)

$S_v = 1$ ft : $z = 0.8(2.6)/7.32 = 0.2$ ft (not applicable)

$S_v = 0.66$ ft

$z = \frac{0.8(2.6)}{7.32(0.67)} = 0.42$ ft $\Rightarrow$ use 0.66' vertical spacing at all wall heights (one block layer

(2) embedment length

$\sigma_h S_v FS = 2 L_e C_i \sigma_v \tan \delta C_r$

$L_e = \frac{\sigma_h S_v FS}{2 C_i \sigma_v \tan \delta C_r} = \frac{104.5(0.07)z(0.67)1.5}{2(0.75)(104.5z \tan 9.33)0.8} = \frac{7.35z}{20.61z} = 0.36$ ft

$L_R = (H - z)\tan(45 - \phi/2)$

$= 15 - z(0.781)$

Retaining Wall - External Stability

- assume 16" spacing of geogrid (2 heights of masonry block)

$S_v = 16" = 1.33 ft.$

$\phi_b = 14°$

$\delta = \frac{2}{3}\phi_b = 9.33°$

$\gamma = 104.5$ PCF

$L = 10'$

① SLIDING:

Resisting Force $= R = W \times \mu = \gamma H L \tan\delta$

$= 104.5(17)(10)\tan(9.33)$

$= 2919$ lb

$FS_{slide} = \frac{R}{P_a} = \frac{2919}{1180} = \boxed{2.5}$

Geogrid Properties:

S_g Tult = 10,000 lb/ft

longitudinal spacing = 2 in

transverse spacing = 4 in

rib width = 1.0 in

rib thickness = 0.15 in

② OVERTURNING:

$M_{stable} = W\left(\frac{L}{2}\right) = \frac{\gamma H L^2}{2} = 78,375$ lb-ft

$M_{overturn} = P_a\left(\frac{H}{3}\right) = 1180\left(\frac{15}{3}\right)$ 5900 lb-ft

$FS = \frac{78375}{5900} = \boxed{13.3}$

③ No tension on footing:

$e = \frac{M_{ov}}{W + qL} = \frac{5900}{\gamma H L + qL^{0}} = \frac{5900}{104.5(15)(10)} = 0.376$ ft

$e < \frac{L}{6} = \frac{10}{6} = 1.67$

$\boxed{0.37 < 1.67}$ ∴ OK - No tension on footing

FBM Engineers 3/8/2001
Geotechnical Calculations

Layer Number	Depth (ft)	spacing (ft)	Le (ft)	Le min(ft)	Lr (ft)	Lcalc (ft)	Lrqd (ft)
21	0.93	0.67	0.36	0.5	14.27367	14.77367	15
20	1.6	0.67	0.36	0.5	13.7504	14.2504	15
19	2.27	0.67	0.36	0.5	13.22713	13.72713	15
18	2.94	0.67	0.36	0.5	12.70386	13.20386	15
17	3.61	0.67	0.36	0.5	12.18059	12.68059	15
16	4.28	0.67	0.36	0.5	11.65732	12.15732	15
15	4.95	0.67	0.36	0.5	11.13405	11.63405	15
14	5.62	0.67	0.36	0.5	10.61078	11.11078	15
13	6.29	0.67	0.36	0.5	10.08751	10.58751	15
12	6.96	0.67	0.36	0.5	9.56424	10.06424	15
11	7.63	0.67	0.36	0.5	9.04097	9.54097	15
10	8.3	0.67	0.36	0.5	8.5177	9.0177	10
9	8.97	0.67	0.36	0.5	7.99443	8.49443	10
8	9.64	0.67	0.36	0.5	7.47116	7.97116	10
7	10.31	0.67	0.36	0.5	6.94789	7.44789	10
6	10.98	0.67	0.36	0.5	6.42462	6.92462	10
5	11.65	0.67	0.36	0.5	5.90135	6.40135	10
4	12.32	0.67	0.36	0.5	5.37808	5.87808	10
3	12.99	0.67	0.36	0.5	4.85481	5.35481	10
2	13.66	0.67	0.36	0.5	4.33154	4.83154	10
1	14.33	0.67	0.36	0.5	3.80827	4.30827	10

1997 Boring Location Plan

Boring Plan Notes

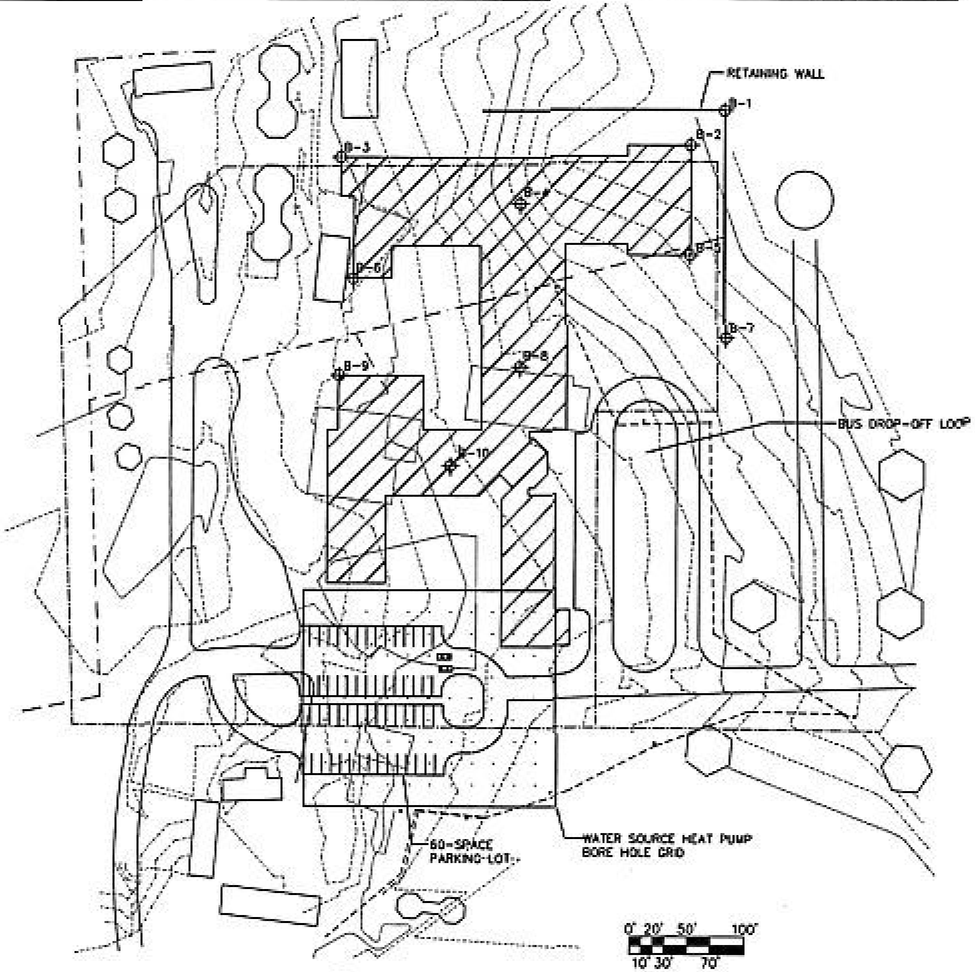
The following boring location plan illustrates the locations of nine borings performed on St. Michael's campus during September, 1997. The information discovered during this site exploration is still valid for the proposed project. However, supplemental borings must be performed in order to generalize the findings for the rest of the proposed new building site.

Proposed Boring Location Plan

Boring Plan Notes

Proposed boring names and locations are noted on the following plan. Borings are spaced approximatley 200 ft. on center in major corridors of the building. Borings should be performed before any other action on the site, including the drilling of the ground source heat pump well grid.

No borings are proposed for the south side of the building because of its proximity to the area already explored by Agra, Inc. in 1997 and the proposed ground source heart pump well grid. After other borings have been performed, a field geotechnical engineer should observe the drilling of the wells and examine cuttings to determine similarities or differences versus the expected fill based on the results of previous sampling. If notable differences in strata are observed, additional borings in the area may be required.



FBM Design	CLIENT ST MICHAELS ASSOCIATION FOR SPECIAL EDUCATION ST MICHAELS, AZ	DRAWING TITLE PROPOSED BORING PLAN	DRAWING NUMBER B-9.2

Appendix C: Architectural Appendix

Wall Construction

The wall construction for the majority of the building will be a 8" masonry wall, a 2" air space, 2" of insulation, and ½" drywall with a steel stud backup. Using this design, the winter conditions of the site require that a vapor barrier is added to keep moisture from accumulating in the wall. See the calculations later in this appendix.

Roof Construction

The roof construction will consist of built-up roofing on top of a layer of 2" insulation which is all supported by 1 ½", 20 gage metal roof deck. This whole construction will be supported by roof joists and beams which bear on the concrete masonry unit walls.

Acoustics

Acoustics is a concern in two areas of the building. The first area is in the sound therapy rooms. The students need a place free from distraction where they can have their hearing testing. FBM suggests a small booth where they are separate from the people doing the testing. A cut sheet has been provided later in this appendix for a room such as this. The other area where acoustics may be a concern is in the gymnasium. FBM suggests the implementation of sound absorbent materials placed in the ceiling to keep sound from echoing throughout the large space.

Overall Building Design

Great care was taken to be sure that the architectural program met the varied needs of the client. St Michaels was happy with the initial program, but had several suggestions for improvement:

- The main suggestion the client gave was an increase of the number of classrooms from six to nine. The client felt that the campus would have expanding needs and therefore need additional classrooms.
- They also expressed a possible need for additional meeting space so two additional conference rooms were added to the office wing. They also requested a 100-seat auditorium space, however FBM was unable to supply this. Instead the

cafeteria was equipped with a large stage area and versatile seating area so that it can be easily transformed into an auditorium setting if necessary.

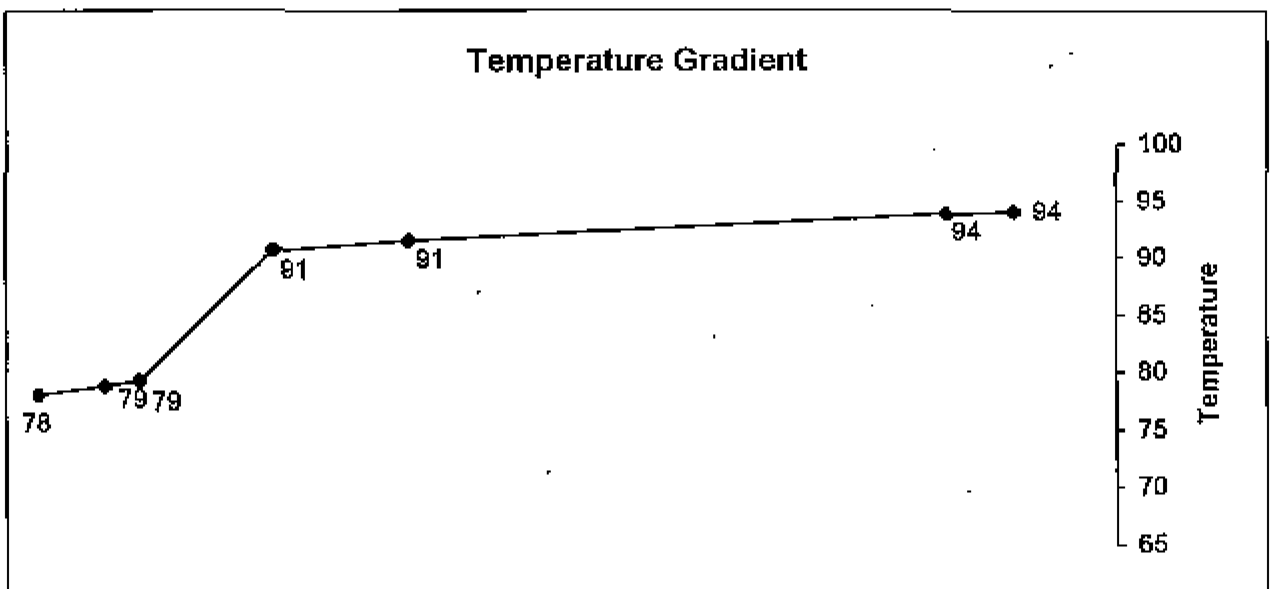
- St Michaels expressed a need for a computer/resource room for the teachers to utilize for email and Internet needs, so a room was added.
- The client wanted to see a staff lounge for their teachers to relax and get away from things for a while. This area should include a kitchenette, vending machines, and couches for seating. This room was also added.
- An expanded nursing staff is expected in the near future of the school, so they asked that the nurse's office be enlarged to accommodate three nurse's offices.
- A more detailed outline of the offices needed was provided to FBM to make the design of the office area easier. This new information made the office area grow. These offices include:
  - Education Administration
    - Director of Education (with secretary)
    - Assistant to the Director of Education
    - Education compliance
    - Family services
    - Social Services
  - Residential Administration
    - Director of Residential (with secretary)
    - Residential Supervisors (3 of them and I'm assuming they could all share an office)
  - Developmental Supports Administration
    - Director of Developmental Supports (with secretary)
    - 1 office for several part time workers

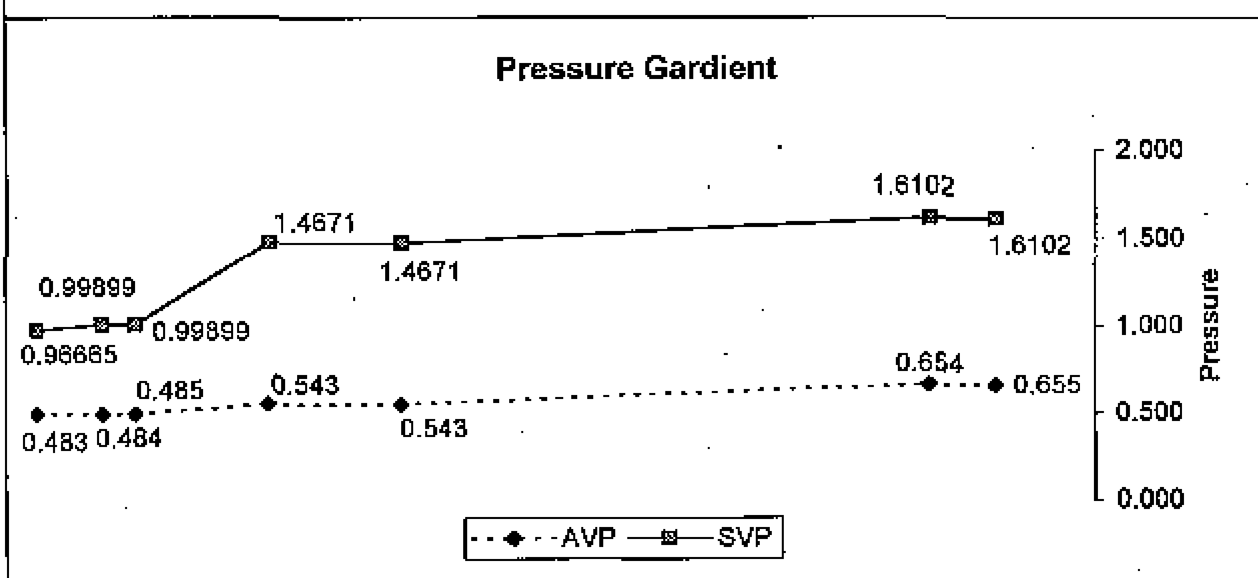
- <u>Administration</u>
    - Executive Director (with secretary)
- <u>Information Technology</u>
    - Director of Technology
    - Office for troubleshooter
- <u>Development Office</u>
    - Coordinator
    - Large work area room
- <u>Business & Operations</u>
    - Director of Business & Operations
    - Assistant to the Director
    - Human Resources office
    - Accounts Receivable/Payable/Accounting Manager (3 people sharing 1 office)

Homework #3

Justin Ruby
AE 544
5/24/01

Summer Conditions							
Description	**R**	**Delta T**	**Temp**	**SVP**	**Rep**	**Delta VP**	**AVP**
Inside Air Temperature			78	0.96665			0.483
Inside Air Film	0.68	1	79	0.99899	0.008	0.000	0.484
1/2" Gypsum Wallboard	0.45	0	79	0.99899	0.02	0.001	0.485
2" Insulation	11	11	91	1.4671	1.25	0.058	0.543
2" Air Space	0.77	1	91	1.4671	0.004	0.000	0.543
8" CMU Wall	2.2	2	94	1.6102	2.4	0.112	0.654
Outside Air Film	0.25	0	94	1.6102	0.008	0.000	0.655
Outside Air Temperature			94	1.6102			0.655
TOTAL	15.4	16			3.69	0.171	

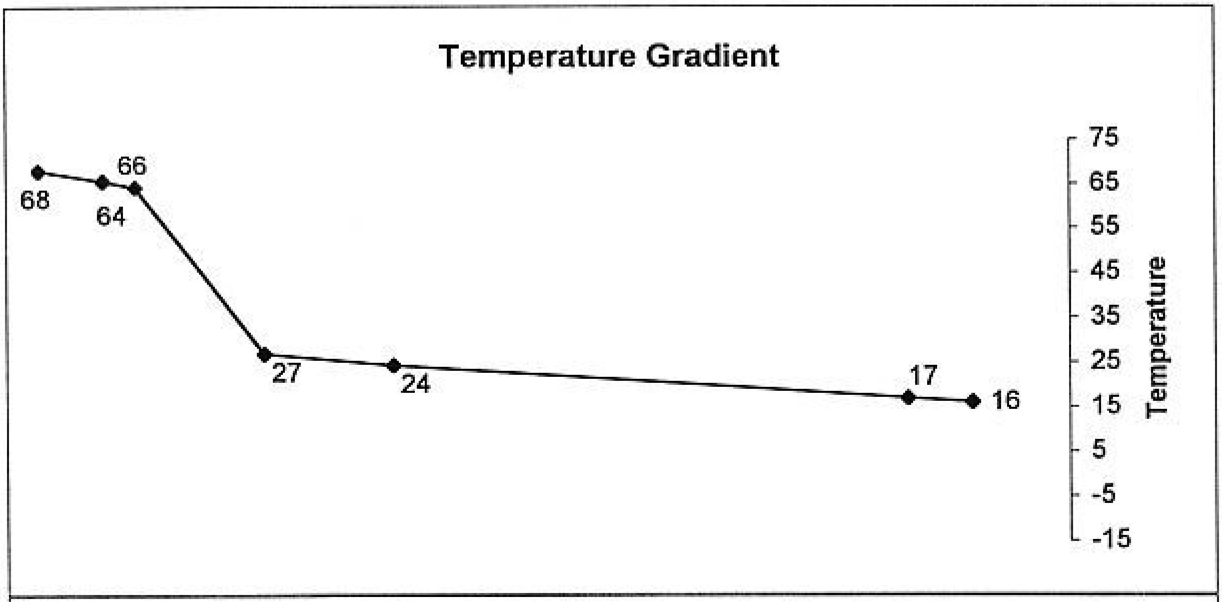


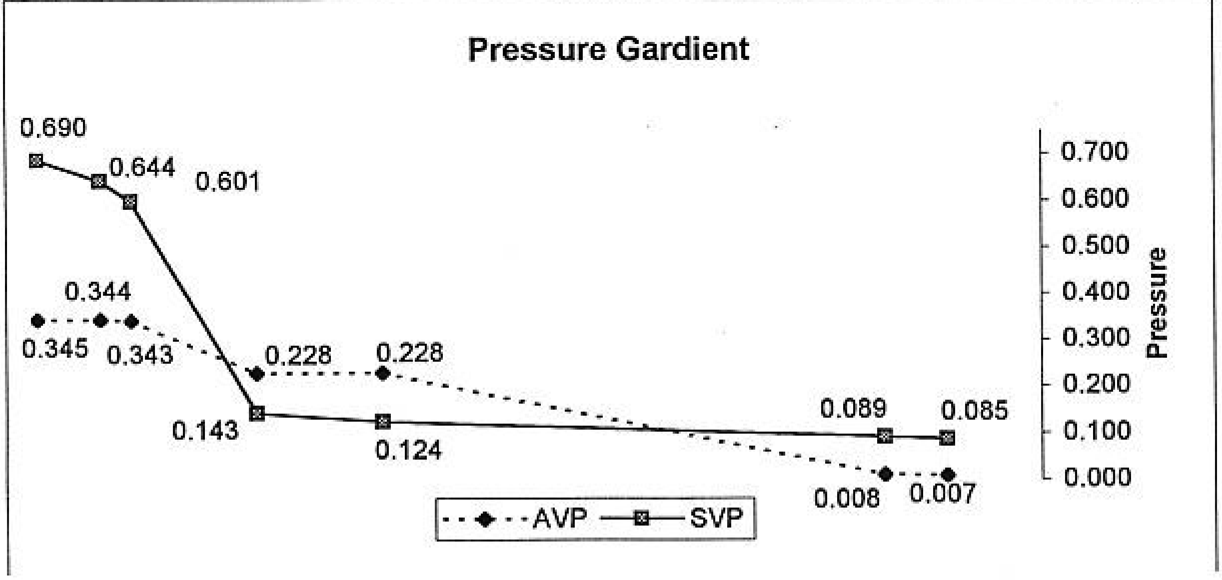


Homework #3

Justin Ruby
AE 544
5/24/01

Winter Conditions							
Description	**R**	**Delta T**	**Temp**	**SVP**	**Rep**	**Delta VP**	**AVP**
Inside Air Temperature			68	0.690			0.345
Inside Air Film	0.68	2	66	0.644	0.008	0.001	0.344
1/2" Gypsum Wallboard	0.45	2	64	0.601	0.02	0.002	0.343
2" Insulation	11	37	27	0.143	1.25	0.114	0.228
2" Air Space	0.77	3	24	0.124	0.004	0.000	0.228
8" CMU Wall	2.2	7	17	0.089	2.4	0.220	0.008
Outside Air Film	0.25	1	16	0.085	0.008	0.001	0.007
Outside Air Temperature			16	0.022			0.007
TOTAL	15.4	52			3.69	0.338	

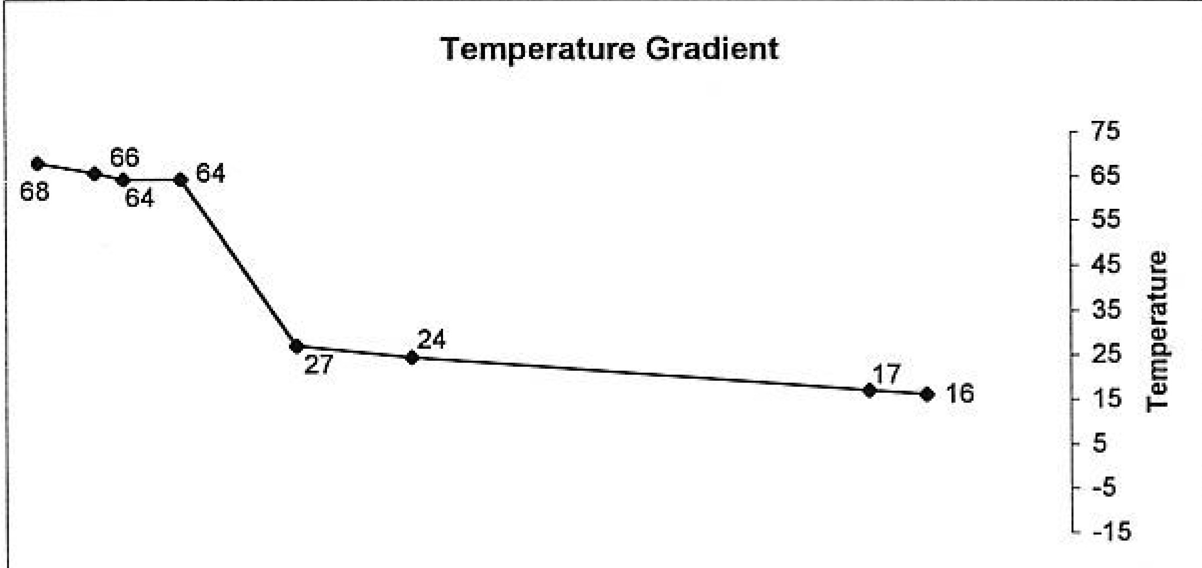


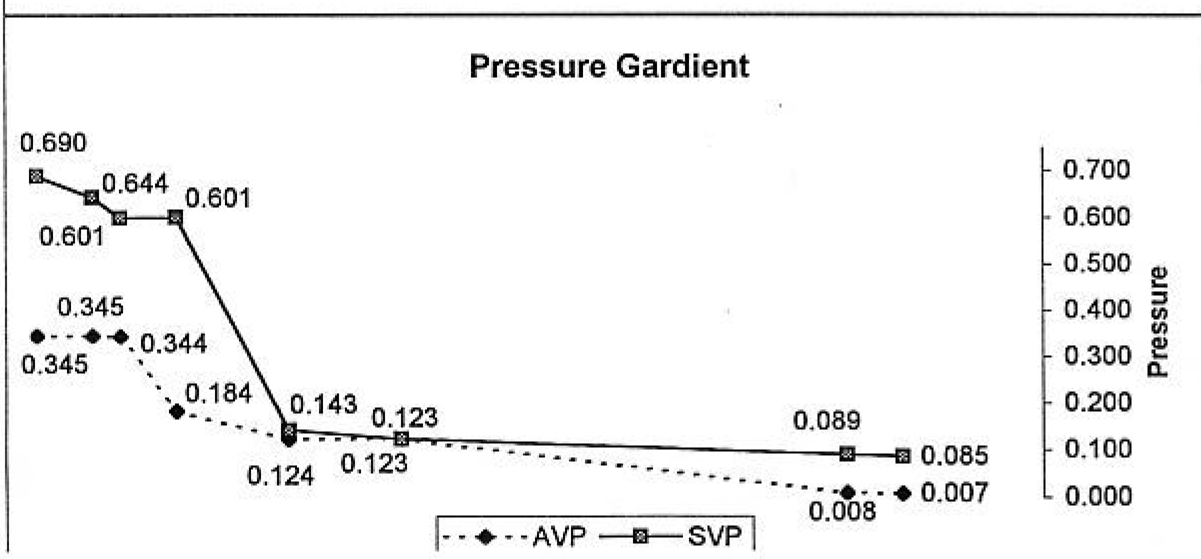


Homework #3

Justin Ruby
AE 544
5/24/01

Winter Conditions							
Description	**R**	**Delta T**	**Temp**	**SVP**	**Rep**	**Delta VP**	**AVP**
Inside Air Temperature			68	0.690			0.345
Inside Air Film	0.68	2	66	0.644	0.008	0.000	0.345
1/2" Gypsum Wallboard	0.45	2	64	0.601	0.02	0.001	0.344
6-mil Polyethylene Sheet	0	0	64	0.601	3.333	0.160	0.184
2" Insulation	11	37	27	0.143	1.25	0.060	0.123
2" Air Space	0.77	3	24	0.124	0.004	0.000	0.123
8" CMU Wall	2.2	7	17	0.089	2.4	0.115	0.008
Outside Air Film	0.25	1	16	0.085	0.008	0.000	0.007
Outside Air Temperature			16	0.022			0.007
TOTAL	15.4	52			7.024	0.338	





Homework #4

Justin Ruby
AE 544

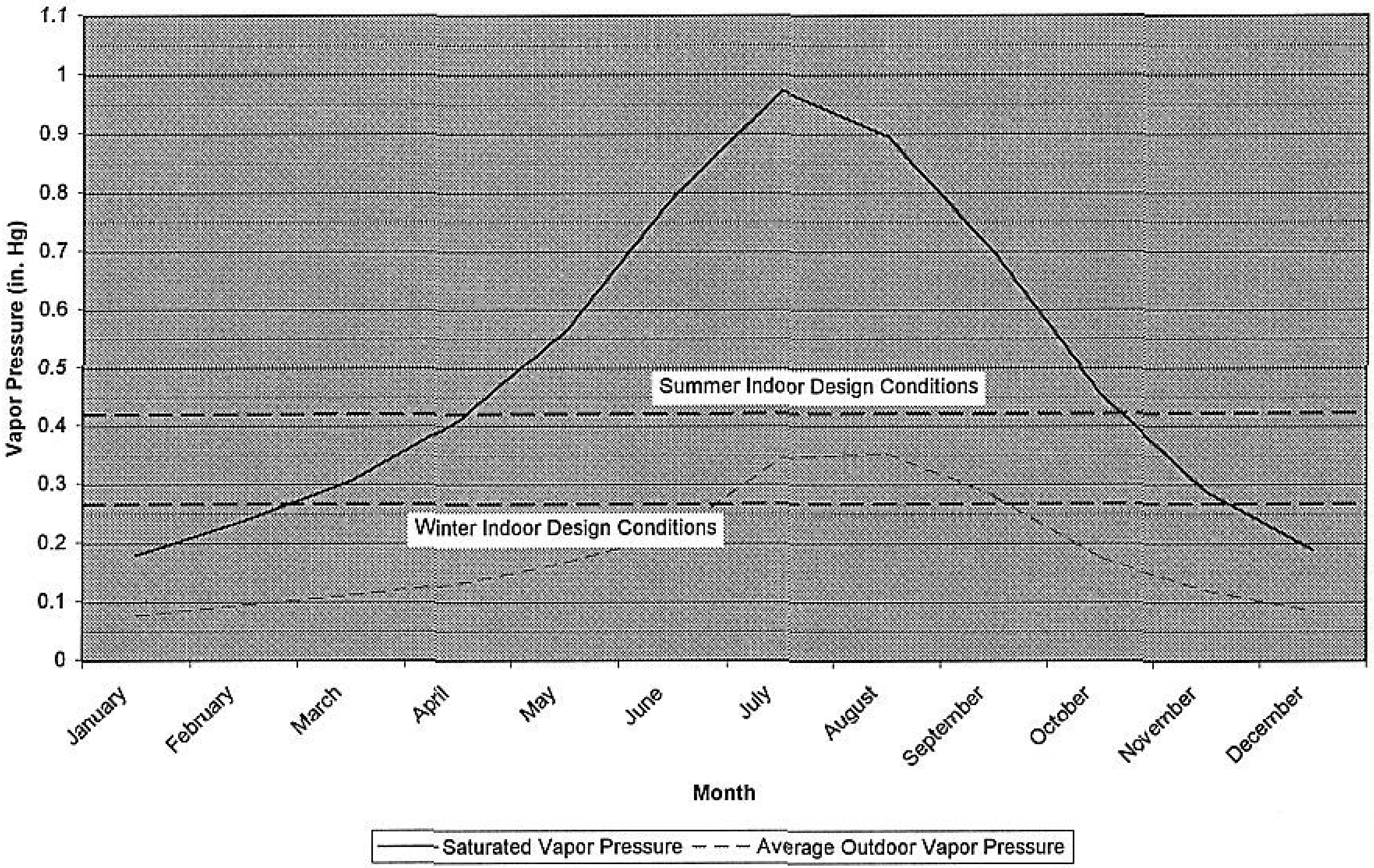
Month	Mean Outdoor Temp	Saturated Vapor Pressure	Average Outdoor RH	Average Outdoor VP	Winter Wetting	Winter Drying	Summer Wetting	Summer Drying
January	31.9	0.179542	42.5	0.07628	0.304068		0.165848	
February	39	0.23819	40	0.09525	0.24542		0.1072	
March	*45.5*	*0.30604*	*36.5*	*0.11166*	*0.17757*		*0.03935*	
April	53.3	0.409456	32	0.13098	0.074154			0.064066
May	62.3	0.565964	29.5	0.16692		0.399044		0.399044
June	72.2	0.796552	27	0.21525		0.581302		0.581302
July	78.2	0.973118	35.5	0.34579		0.627328		0.627328
August	75.7	0.895802	39.5	0.35415		0.541652		0.541652
September	68.2	0.695012	40.5	0.2817		0.413312		0.413312
October	56.2	0.455086	38.5	0.17532	0.028522			0.109698
November	43.9	0.287904	41.5	0.11944	0.195706		0.057486	
December	33.1	0.188458	45	0.08482	0.295152		0.156932	
Totals					1.320592	2.562638	0.526816	2.736402

Winter Indoor Design Conditions:	
Air Temperature:	78
Relative Humidity:	50
Vapor Pressure:	0.48361

Summer Indoor Design Conditions:	
Air Temperature:	68
Relative Humidity:	50
Vapor Pressure:	0.34539

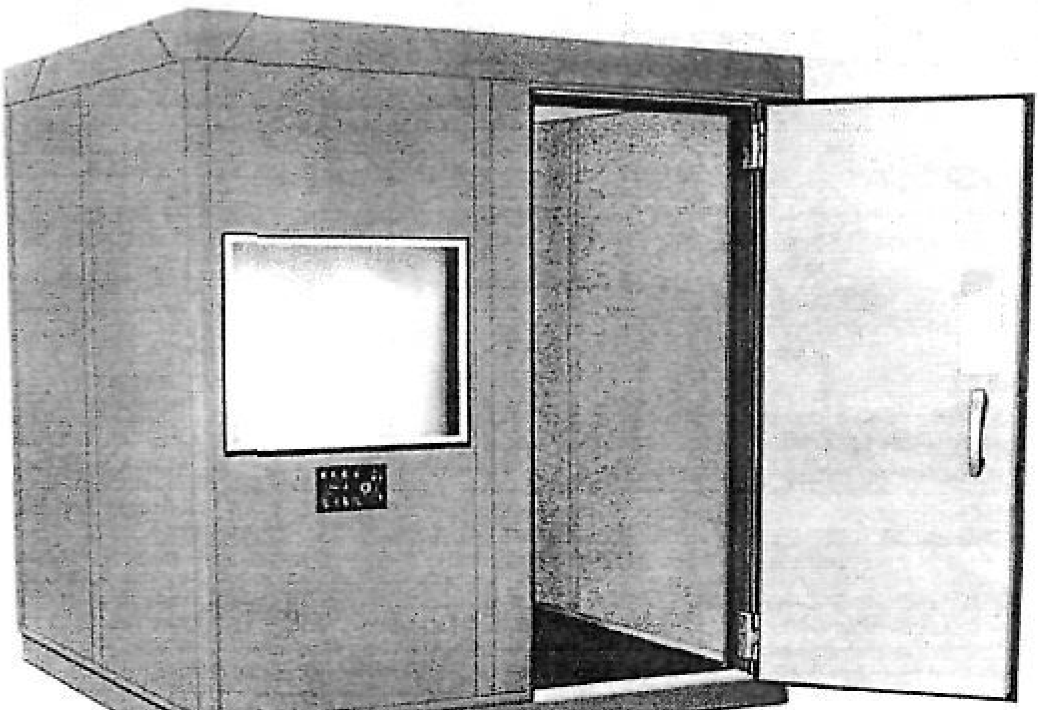
Mean Outdoor Temperature Information Courtesy of:
http://www.ncdc.noaa.gov/ol/climate/online/ccd/meantemp.html
Average Outdoor Relative Humidity Information Courtesy of:
http://www.ncdc.noaa.gov/ol/climate/online/ccd/avgrh.html
Average Outdoor Vapor Pressure Calculated Using:
http://www.linric.com/webpsy.htm

Philadelphia Industrial Building Wetting and Drying Cycles



BULLETIN 5.0101.6
400-A SERIES

ROOMS FOR THE MEDICAL AND LIFE SCIENCES



~~Fourth~~ Fifth Generation IAC Sound Isolation Rooms Feature:

- ***Textured Steel Finish — outside and inside surfaces***
- ***Aluminum-Trim "Pressure-Sealed" acoustic window***
- ***Interchangeable panels***
- ***"spaSAVER®" ventilation built into roof panels***

•STATE OF THE ART NOISE REDUCTION DATA • TYPICAL REVERBERATION TIMES • FLUSH-MOUNTED DOORS • CAM-LIFT HINGES
•GRAVITY THRESHOLD COMPRESSION SEALS • MAGNETIC DOUBLE NOISE-LOCK* PERIMETER SEALS • PROVEN PERFORMANCE

controlled environments for acoustics/r.f/60 cycle/vibration/temperature/humidity

iac INDUSTRIAL ACOUSTICS COMPANY

*Protected under U.S. Patent No. 3,789,747

400–A SERIES

IAC pioneered the development of prefabricated rooms for the Medical/Life Sciences. "400–A" Series Rooms are the most widely used rooms of their kind. Thousands are in successful operation throughout the United States and abroad.

All types of measurements requiring the exclusion of sound can be made inside these rooms when located in areas of "normal" ambient. The definition of "normal" may vary with the type of measurements involved. Our Advisory Services, utilizing the latest sound measuring equipment, are available for consultation at no charge.

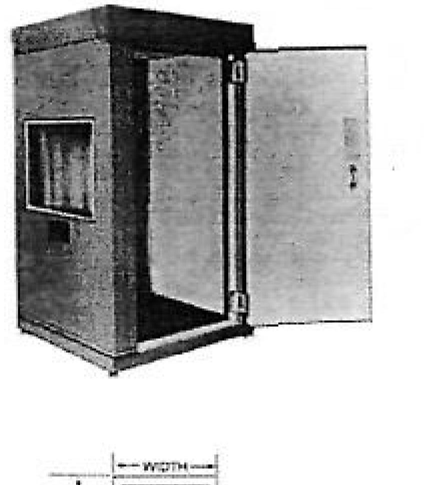
Rooms are constructed of 4 in. (102mm) modular panels and provide the required acoustic environment to conduct valid pure tone air- and bone-conduction tests, speech tests, and audiological, psychological, heart sounds, auscultation and cardiography examination and research. Models are designed for either individual or multiple occupancy.

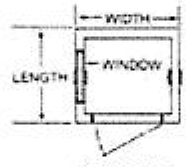
All rooms are supplied with top performance Noise-Lock® Doors with flush-mounted, cam-lift, butt-type hinges, double positive magnetic seals at head and jamb which effect a sound-absorbing labyrinth. Harnessing the principles of gravity and magnetism, these unique doors achieve reliable in-field acoustical performance. A sound-tight seal results as the cam action of IAC's unique hinges compress the bottom seal firmly against the sill eliminating a hazardous step into the room.

IAC "spaSAVER™" forced ventilation intake and discharge silencer systems are standard equipment and built into the roof panels. The ventilation system matches the acoustical environment provided by the room itself. Perfected after years of R&D in our own Aero-Acoustic Laboratory, it is the finest and only one of its type.

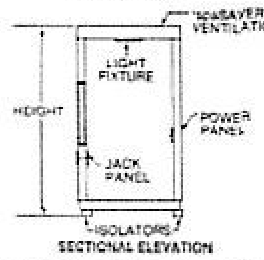
Rooms may also be directly coupled to an existing air conditioning system via flexible connections. Additional packaged sound attenuators in the air conditioning intake and exhaust lines may be required and supplied.

More than 300 types of configurations and layouts are available. These provide for the interchangeability of window, door, roof, power panels, and other components.





PLAN SECTION



SECTIONAL ELEVATION

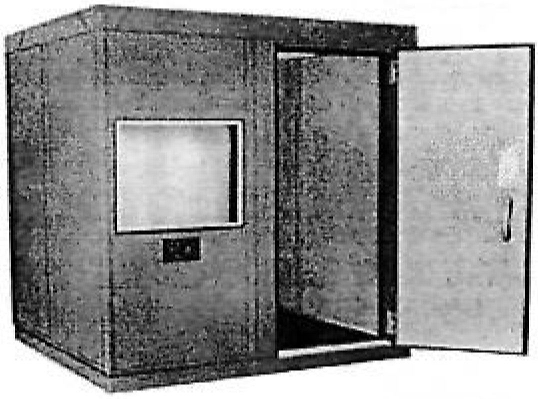
STANDARD ROOM FEATURES

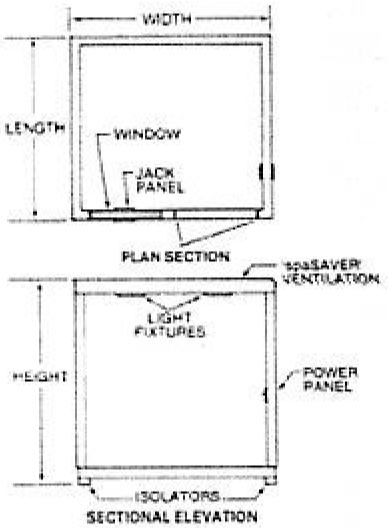
1. IAC "spaSAVER™" ceiling panels containing an all-in-one forced ventilation system with built-in intake and exhaust silencers.
2. *Models 400–A and 401–A are available in two types of configurations permitting door and window panel variations.* Models 402–A, 403–A, 404–A, and 405–A are available in over 300 types and configurations.
3. Four-inch-thick (102mm) durable non-combustible Noise-Lock steel panels with noise reduction coefficients of 0.95 (1.10) as tested in a recognized independent and approved acoustical laboratory.
4. Acousti-Flote™ floor on rubber vibration isolators.
5. Specially designed 2½ in.-thick (64mm) Noise-Lock Flush Mounted Cam-Lift Magnetic Seal Door.
6. Double-glazed 24 in. x 30 in. (610mm x 762mm) Noise-Lock window.
7. Jack Panel. See item 9 on back page of this Bulletin for detailed specifications on jack panel.
8. Recessed incandescent light fixtures prewired with power cord for connection to power panel.
9. Power panel (factory prewired and Hospital Grade)
   interior –two (2) rocker switches for lights and fans.
   –one (1) duplex receptacle.
   exterior –two (2) duplex receptacles to plug-in light and fans.
   –one (1) 10 ft (3048mm) long power cord for connection to standard 110 V outlet.
10. Carpet.
11. Color: Desert Sands.

OPTIONAL EQUIPMENT

AVAILABLE AT ADDITIONAL COST

1. Noise-Lock double-glazed 12 in. x 12 in. (305mm x 305mm) window in door.
2. Additional Noise-Lock double-glazed windows.
3. One-way glass Noise-Lock window substituted for standard.
4. One-way Noise-Lock glass on sliding rails.
5. Light-tight shades with frames.
6. Quiet fluorescent lights with remote ballasts.
7. Intercom system.
8. RF and electrostatic shielding.
9. Power filters.
10. Outside wood grain vinyl finish.
11. Special outside or inside paint colors.
12. Special jack panels, cutouts and plugs.
13. Humidity and temperature control.
14. Recessed keyed locks.
15. Teak formica shelves.
16. Six-outlet plug-in power strip.
17. U.L. fire-resistant panels and door construction.





REVERBERATION TIMES

⅓ OCTAVE BAND CENTER FREQUENCY, Hz	125	250	500	1K	2K	4K	8K
SECONDS	0.24	0.19	0.11	<0.1	<0.1	<0.1	<0.1

NOISE REDUCTION

⅓ OCTAVE BAND CENTER FREQUENCY, Hz	125	250	500	1K	2K	4K	8K	NIC
NOISE REDUCTION, dB*	28	36	48	57	61	61	57	50

± 3 dB for instrument accuracy

SELECTED DESIGN DATA — 400-A SERIES ROOMS

MODEL	DIMENSIONS ft-in, mm						ROOM WT.	VENT SYSTEM
	INSIDE			OUTSIDE				
	W	L	H	W	L	H	lb kg	cfm m³/min
400	3'-4" 1015	3'-0" 915	6'-6" (1980)	4'-0" 1220	3'-8" 1120	7'-6" (2290)	1,800 820	100 2.85
401	4'-0" 1220	3'-4" 1015		4'-8" 1425	4'-0" 1220		2,100 950	100 2.85
402	6'-4" 1930	6'-0" 1830		7'-0" 2135	6'-8" 2035		3,475 1,580	200 5.66
403	7'-4" 2235	7'-0" 2135		8'-0" 2440	7'-8" 2340		4,160 1,890	200 5.66
404	9'-0" 2745	8'-4" 2540		9'-8" 2945	9'-0" 2745		5,250 2,380	200 5.66
405	10'-0" 3050	9'-4" 2845		10'-8" 3250	10'-0" 3050		6,125 2,780	300 8.50

ALSO AVAILABLE IN OTHER SIZES AS REQUIRED.

NOTE: Height 7'-6" (2286mm) — will fit under 8'-0" (2438mm) ceiling

ACOUSTICAL AND STRUCTURAL SPECIFICATIONS FOR IAC SERIES "400-A" EXAMINATION AND RESEARCH ROOMS

1. Medical Rooms

Rooms shall be Model Number ***(insert as required)*** manufactured by Industrial Acoustics Company, Inc., 1160 Commerce Avenue, Bronx, New York 10462.

2. Roof and Wall Panels

Roof and Wall panels shall be made of not less than 14 gauge (1.9mm) cold rolled TEXTURED steel (CRS) outside surfaces and 22 gauge (0.76mm) galvanized perforated TEXTURED steel inside surfaces with ³⁄₃₂ in. (2.36mm) diameter openings of ³⁄₁₆ in. (4.76mm) staggered centers, reinforced with 18 gauge (1.21mm) CRS channels for rugged metal frame. Average weight to be not less than 8 lb/sq ft (39 kg/sq m).

3. Floor Construction

Acousti-Flote™ floor shall be 4 in. (102mm) thick with 11 gauge (3.04mm) hot rolled steel (HRS) upper surface and 16 gauge (1.52mm) CRS bottom sheets structurally reinforced. All floors shall be covered with carpeting. Average weight to be not less than 10 lb/sq ft (49 kg/sq m). Floors shall float on properly loaded isolators rated for natural frequency of 6¼ Hz for maximum elimination of structural noise.

4. Acoustic Infill

Infill for floors, walls, door, and roof panels shall be sound-retardant, absorbing, inert, mildew-resistant, and vermin-proof. It shall have U.L. fire hazard classification of not less than: Flame Spread-0; Smoke Developed-5; Fuel Contributed-0. Heat transfer factor shall be no more than 0.07 BTU/hr ft²°F.

5. Door Construction

IAC Noise-Lock* Flush-Mounted Cam-Lift magnetic-seal doors shall be provided with clear opening of 33 in. (838mm) wide x 73½ in. (1867mm) high. Door leaf shall be fabricated of 16 gauge (1.52mm) cold rolled TEXTURED steel, inner and outer sheets. Sides and head of door and frame shall receive two (2) sets of selfaligning MAGNETIC COMPRESSION

continued

SEALS. Acoustic labyrinth shall be created when door is in closed position. Bottom of door leaf shall contain continuous gravity activated seal which shall compress against floor as door is closed. RAISED SILL AND THRESHOLD DROP SEALS NOT PERMITTED.

Hardware shall include two (2) cam-lift butt-type hinges finished in U.S. 26-D satin chrome. SURFACE MOUNTED HINGES NOT ACCEPTABLE. Latches shall not be required or permitted to hold door closed or to achieve acoustic seal. Door leaf shall be held closed by the magnetic action of the acoustic seals.

6. Wall and Roof Panel "H" Members
Wall and roof panels shall be acoustically and structurally joined together by "H" members. One piece seamless, non-welded, and roll formed "H" members, constructed of 20 gauge (0.91mm) CRS shall maintain the acoustical integrity of the room.

7. Window Construction
Windows shall be 24 in. (610mm) x 30 in. (762mm) double-glazed ¼ in. (6.35mm) thick safety glass with "pressure-sealed" ALUMINUM TRIM FRAME.

8. Jack Panel
A jack panel consisting of ten (10) Switchcraft 3-wire phone-type jacks with covers, one (1) each Cinch Jones Series No. 303 and 304 connectors, and two (2) 1-inch (25.4mm) ID grommeted holes shall be provided under the window. On Models 400-A and 401-A jack panel shall consist of six (6) Switchcraft and one (1) each Cinch Jones No. 303 and 304. Jack Panels shall be designed to preserve acoustical integrity of the room.

9. Electrical
All components shall be UL approved and Hospital Grade. All wiring shall be in accordance with the National Electric Code.

All Series rooms shall be provided with recessed incandescent lights and a factory wired "power panel" consisting of: ***Interior*** – Two (2) rocker switches to control lights and fans independently. One (1) duplex outlet. ***Exterior*** – Two (2) duplex outlets to plug in lights and fans. One (1) 10 foot (3048mm) long power cord and plug for connection to a 110V/60 Hz power supply.

10. Ventilation Systems
spaSaver™ ceiling panels containing an all-in-one integrated Tranquil-Aire® ventilation system with built-in intake and exhaust silencers or a packaged Tranquil-Aire ventilation system, roof or wall mounted shall be provided. Where rooms are directly coupled through a flexible duct to a building AC system, supplementary IAC Quiet Duct Silencers (optional) are available for installation in the duct work by others.

11. Fire Rating— *(Recommended Option)*
Rooms shall be constructed of Fire-Noise-Lock* Panels fire rated by U.L. for 90 min. with sound absorptive surfaces facing fire inside room. Rating for solid surfaces facing fire outside room shall not be less than 60 min. Each Fire-Noise-Lock Panel shall bear a label with Listing Mark of Underwriters Laboratories, Inc. certifying dual ratings.

12. Noise Reduction*
The minimum allowable noise reduction of completely assembled rooms as tested in accordance with ASTM Designation: E 596 shall be as shown in table below.

1/1 Octave Band Center Frequency, Hz	125	250	500	1K	2K	4K	8K	NIC
Noise Reduction, dB**	28	36	48	57	61	61	57	50

*Defined as the difference between sound pressure-level in a reverberation room outside the booth and that inside the booth. Copy of Laboratory Report available on request.

**± 3dB for field instrument accuracy.

NIC — Noise Isolation Class, single number rating system for noise reduction characteristics.

13. Reverberation Times (RTs)
Typical reverberation times as measured in a completely assembled room are as follows:

⅓ Octave Band Center Frequency, Hz.	125	250	500	1K	2K	4K	8K
Seconds	0.24	0.19	0.11	‹0.1	‹0.1	‹0.1	‹0.1

14. Finish
Degrease and clean all metal surfaces with welds ground smooth and filled as needed. Coat with rust inhibitive chromate modified alkyd primer. Finish with cellulose-nitrate polyester modified coating per quality standards of National Association of Architectural Metal Manufacturers. Color: Desert Sands.

15. Erection Procedure
Rooms shall be so engineered as to allow the installation of this equipment within 4 in. (102mm) of an existing wall.

16. Supplier's Experience
The contractor shall provide proof that he has trained personnel and his own shop facilities for performing the work under established quality-control procedures.

17. No Exception To This Specification Allowed.

All designs and specifications subject to change without notice. Dimensions nominal.

iac
THE STANDARD OF SILENCE

INDUSTRIAL ACOUSTICS COMPANY
SINCE 1949 — LEADERS IN NOISE CONTROL ENGINEERING, PRODUCTS AND SYSTEMS

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BRONX, NEW YORK 10462-5599
PHONE: (718) 931-8000
FAX: (718) 863-1138

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FAX: (02163) 80618

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BULLETIN 3.0601.2

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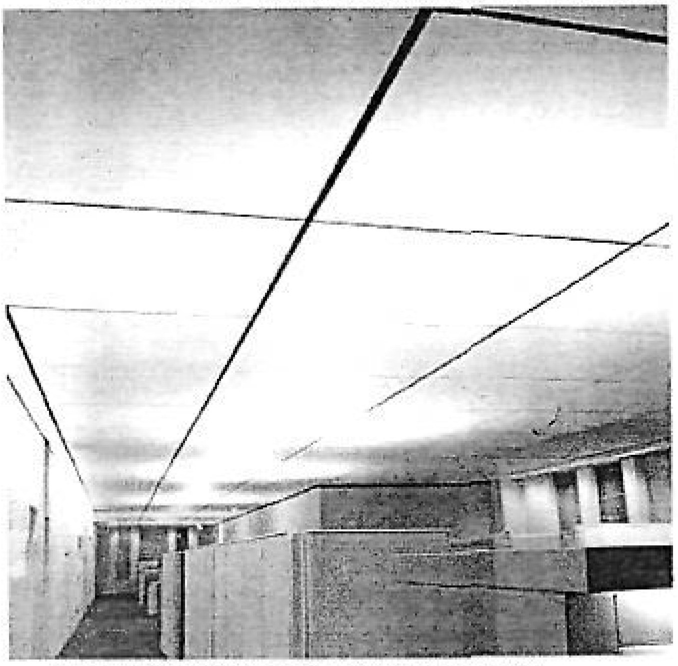
THE STANDARD OF SILENCE

NOISE-LOCK® CEILING SYSTEMS

• SOUND ABSORPTION • TRANSMISSION LOSS • MODULAR FLEXIBILITY
• CUSTOM AND STANDARD DESIGNS • FULLY ENGINEERED AND TESTED



AT&T BUILDING, NEW YORK, N.Y., JOHNSON/BURGEE, ARCHITECT A

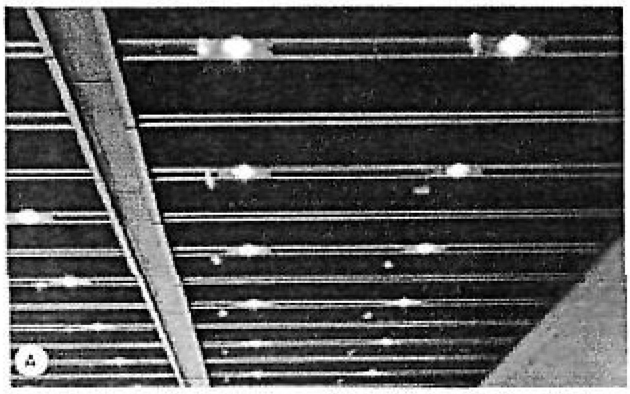
R.J. REYNOLDS, WINSTON-SALEM, N.C., RUST INTERNATIONAL, ARCHITECT &
PHILIP MORRIS, CONCORD, N.C., MARCEL BREUER ASSOCIATES, ARCHITECT B

INDUSTRIAL ACOUSTICS COMPANY

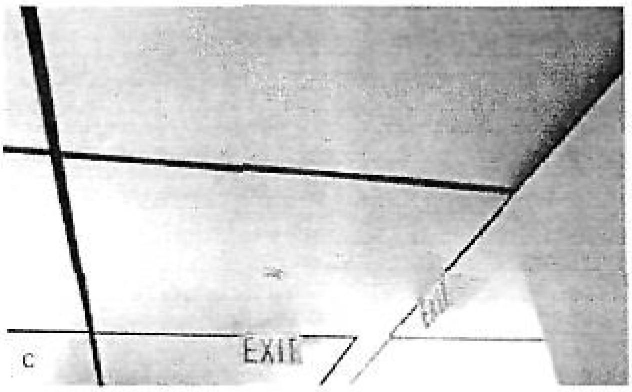
NOISE-LOCK® CUSTOM CEILING SYSTEMS

Since 1949, IAC has been engaged in developing products and systems to solve noise control problems. These range from containing the high noise levels of jet engines to the design and construction of ultra-quiet anechoic chambers to measure noise levels below the threshold of human hearing. Working with owners, architects, and consultants, IAC has also been intensively involved in the design and installation of innovative integrated ceilings to meet the needs of our new space-age and high-technology society.

Utilizing the IAC Aero-Acoustic Laboratory, highly successful custom designs were developed and installed. In the following, we describe five of these Noise-Lock Ceiling Systems, from Mark I to V, and also the original Varitone™ I and II Systems. This experience and accumulated technology is available to solve your noise-control and sound-conditioning problems.



A



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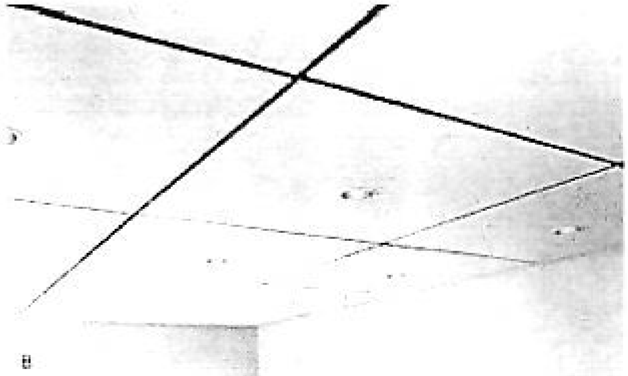

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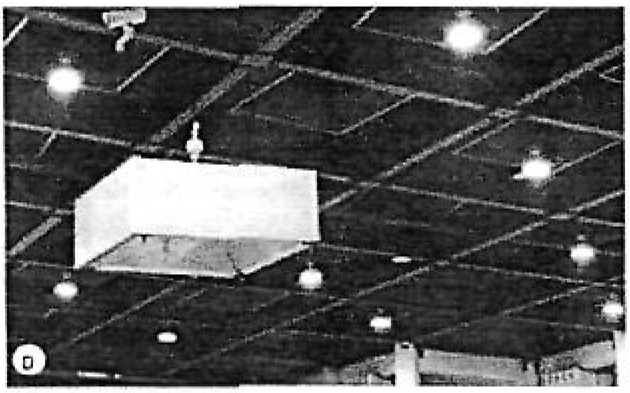


D

A. Philip Morris — Concord, North Carolina — Designed to meet the special requirements of tobacco manufacturers, this load bearing IAC **Mark I** Integrated Ceiling was developed for the owner and architect [illegible] It was supplied in factory fabricated modules with built-in lights and vent air diffusers approximately 26 ft (7925 mm) x [illegible] for speedy field installation. The top surface of each was designed to serve as a work platform to allow for maintenance of the building services located above the acoustical ceiling. This unique ceiling was [illegible] for ease of maintenance and [illegible]. The exposed perforated surface was treated with special screen to prevent the infiltration of dust and insects. **B. Patscenter International Princeton (NJ) Labs.** IAC **Mark II** Ceiling System developed for architects [illegible]

A British based pharmaceutical company required a ceiling panel system that would be easily cleaned, meet rigid FDA regulations, support live construction and maintenance loads, and be pleasing in appearance. Our [illegible] engineering team responded with a flat, ultra smooth, vinyl coated [illegible] The high strength panel surpassed the [illegible] **Mark IV** panel system and [illegible]

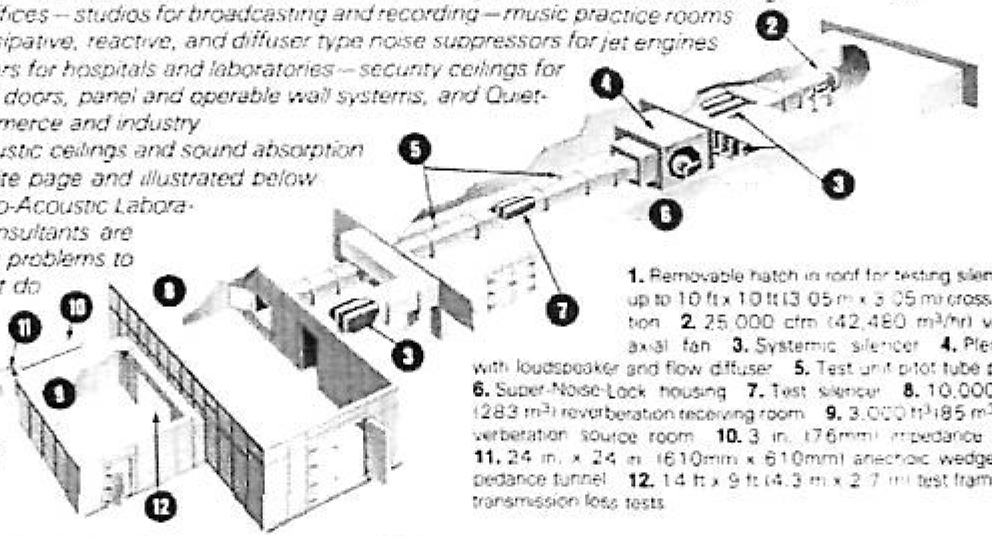
C. AT&T — New York, New York — Developed to satisfy the rigid requirements of Johnson Burgee and AT&T, the IAC **Mark II** Ceiling System is totally integrated and flexible with power track for task lighting and quiet ventilation (NC 35). This 60 in. (1524 mm) x [illegible] ceiling steel panel module is finished with [illegible] perforated steel for long life and low maintenance. It offers excellent sound absorption (NRC 0.90) and attenuation (NIC 45) which eliminates the requirement for separate sound barriers above the ceiling relative to the demountable ceiling-connected partitions below. **D. Varitone II** was developed to solve a severe problem in the Washington D.C. Convention Center. Highly reflective surfaces created a reverberation time of 8 seconds in Center Hall A. This made it difficult for an audience to enjoy a concert or clearly understand speech. After a survey, it was recommended that sound absorptive treatment be applied to the walls and ceiling. One difficulty was ability to install it without interfering with existing lighting, ventilation, audio system, and other services.

Other criteria were rugged construction and resistance to dust and air [illegible]. An acoustic baffle system was developed which met all specifications and provided maximum absorption for its surface area and geometry [illegible]. The installation reduced the reverberation time from a [illegible] 8 seconds to [illegible] seconds. The Convention Center can now schedule a great variety of events without concern thanks to the acoustical performance of Varitone II.

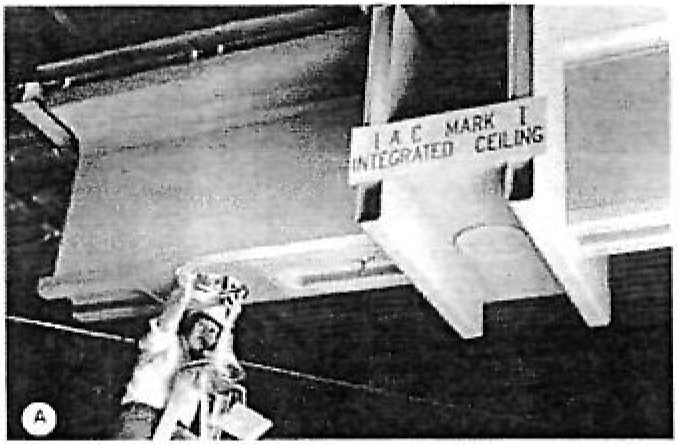
AEROACOUSTIC LABORATORY

The IAC Aero-Acoustic Laboratory has generated a series of "firsts" in the development of noise-control equipment and engineering solutions to noise- and sound control problems. These range from audiometric testing rooms for hospitals and doctors offices — studios for broadcasting and recording — music practice rooms for schools and universities to dissipative, reactive, and diffuser type noise suppressors for jet engines — Clean-Flow™ ventilation silencers for hospitals and laboratories — security ceilings for correctional facilities — soundproof doors, panel and operable wall systems, and Quiet-Flow® Air Handling Units for commerce and industry.

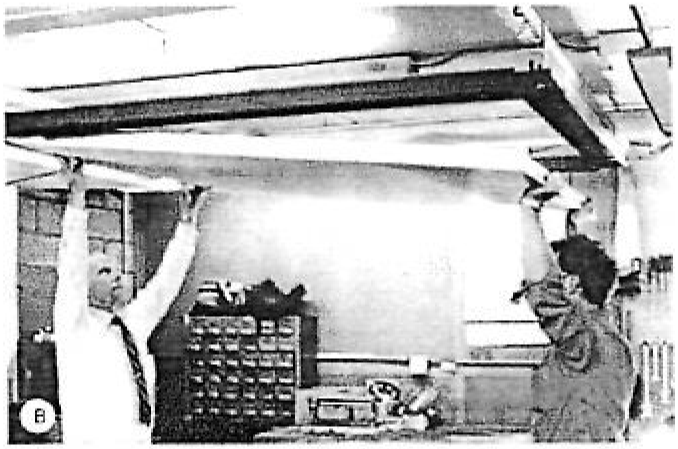
Other "firsts" in integrated acoustic ceilings and sound absorption systems are described on opposite page and illustrated below under development in the IAC Aero-Acoustic Laboratory. Owners, architects, and consultants are encouraged to bring their acoustic problems to IAC. If a standard product will not do the job, IAC will develop a custom solution and guarantee the result. Research, development, and willingness to assume single-source turnkey responsibility is a continuous commitment at IAC.

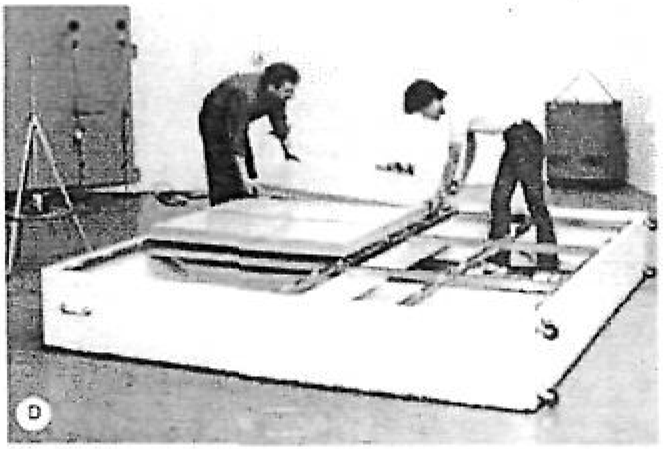


1. Removable hatch in roof for testing silencers up to 10 ft x 10 ft (3.05 m x 3.05 m) cross section. **2.** 25,000 cfm (42,480 m^3/hr) vane-axial fan. **3.** Systemic silencer. **4.** Plenum with loudspeaker and flow diffuser. **5.** Test unit pitot tube ports. **6.** Super-Noise-Lock housing. **7.** Test silencer. **8.** 10,000 ft^3 (283 m^3) reverberation receiving room. **9.** 3,000 ft^3 (85 m^3) reverberation source room. **10.** 3 in. (76mm) impedance tube. **11.** 24 in. x 24 in. (610mm x 610mm) anechoic wedge impedance tunnel. **12.** 14 ft x 9 ft (4.3 m x 2.7 m) test frame for transmission loss tests.



A. Mockup to demonstrate integration of services and accessibility for IAC Mark I Noise-Lock® Ceiling for Philip Morris. **B.** Mockup depicting downward accessibility of 60 in. x 66 in. (1524mm x 1676mm) ceiling modules weighing 70 lb (32 kg) for AT&T. **C.** Mockup of interstitial load bearing IAC Mark IV Noise-Lock Ceiling module, 48 in. x 60 in. (1219mm x 1524mm) supporting a concentrated load of over 250 lb (113 kg). Ceiling serves as work platform for maintenance of mechanical equipment loaded above. **D.** IAC Mark V Noise-Lock Ceiling modules being installed in ASTM E 400 test frame to determine sound absorptive properties for R. J. Reynolds.





NOISE-LOCK® STANDARD CEILING SYSTEMS

IAC Standard Ceiling Systems are the result of custom research work which produced the standard designs now available for a great variety of applications. These modules contain open or encased sound absorbing elements. Three types are described below. Each is an economical, all-metal, fire-resistant module manufactured on modern high-speed machinery which can be installed with most available grid, lighting, and diffuser systems.

The IAC Mark III, IV, and V designs can be furnished in designer demand dimensions of up to 60 in. (1524mm) x 66 in. (1676mm) and in rectangular as well as special modules. The creative imagination of most designers can be satisfied with the great variety of materials/finishes available with IAC Standard Ceiling Systems. These include painted, vinyl coated, stainless steel, aluminum, solid or perforated in flat or rigidized sheets. IAC can provide a truly remarkable high-performance, acoustic, integrated ceiling system with custom features at lower than custom cost. Contact us for details, specifications, and application information. We have qualified representatives in most areas.

IAC NOISE-LOCK MARK

IAC Noise-Lock® Mark III Ceiling System – 2 in. (51mm) Thick — A lay-in or concealed grid metal panel system which provides sound absorption and optional sound transmission loss properties. Available in standard or micro-perforated patterns, the painted or vinyl coated Mark III ceiling panel can be installed with conventional grid systems, lights, and diffusers. Sound transmission loss data applies to backed panel only.

SOUND TRANSMISSION LOSS																	SOUND ABSORPTION COEFFICIENTS						
Center Frequency, Hz 1/3 Octave Band																	Center Frequency, Hz 1/1 Octave Band						
125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	STC	125	250	500	1000	2000	4000	NRC
22	27	27	21	22	25	29	29	32	36	38	38	42	42	43	42	33	63	71	98	1 11	1 09	1 08	0.95

Tests per AMA Two Room Method and ASTM E 413 — Tests per ASTM C 423 and E 795 – Type E 400 Mounting

IAC NOISE-LOCK MARK

IAC Noise-Lock® Mark IV Interstitial System – 2½ in. (64mm) Thick — A loadbearing panel module used to create an interstitial working surface for maintenance and access to services and production equipment above the ceiling. Panel modules 48 in. (1219mm) x 60 in. (1524mm) have been laboratory- and field-tested to support concentrated loads of 250 lb (113kg) each. This hard surfaced steel or aluminum panel is highly abuse-resistant and can be furnished in easily-cleaned dirt-resistant vinyl or painted surfaces. The contamination-free design is particularly suited to pharmaceutical, food processing, health care, life science, clean- and computer-room applications. (Acoustic data furnished on request.)

PANEL STRUCTURAL CHARACTERISTICS											
48 in. x 48 in. (1219mm x 1219mm) panel simply supported - two sides only. Concentrated load over 1 sq ft (.0929 sq m)											
Load, lb	160	240	320	400	480	Load, kg	72 56	108 84	145 12	181 40	217 56
Deflection, in.	024	035	044	054	063	Deflection, mm	610	889	1 118	1 372	1 600

It should be noted that at a load of 480 lb (217.7 kg), the resultant deflection is substantially less than the most stringent deflection criteria. For heavier loads and/or spans greater than 48 in. (1219mm), contact the home office.

IAC NOISE-LOCK MARK

IAC Noise-Lock® Mark V Ceiling System – 2 in. (51mm) Thick Steel — A regressed grid panel system with the attractive shadow-line look provides high sound absorption with options for required sound transmission loss characteristics, protection against particulate matter contamination, and fire-resistance ratings. *Available in solid and micro-perforated surfaces, the Mark V system also provides excellent low-frequency sound absorption and resistance to insect- and dust-infiltration.*

When used as a sound transmission loss element, or noise-control barrier, the Mark V panel system integrates with the IAC Moduline® ceiling-connected partitions to create an acoustically tight intersection. Bothersome above-ceiling sound barriers are not required and the partitions can be relocated with no loss in noise reduction and acoustical privacy. Sound Transmission loss data applies to backed panel only.

SOUND TRANSMISSION LOSS																	SOUND ABSORPTION COEFFICIENTS						
Center Frequency, Hz 1/3 Octave Band																	Center Frequency, Hz 1/1 Octave Band						
125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	STC	125	250	500	1000	2000	4000	NRC
21	26	32	35	36	39	42	43	42	46	47	47	44	42	47	53	43	57	90	118	117	102	82	0.95 (1.05)

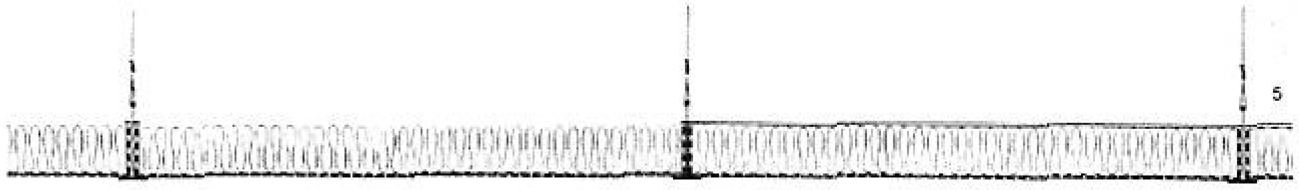
Tests per AMA Two Room Method and ASTM E 413 — Tests per ASTM C 423 and E 795 – Type E 400 Mounting

FEATURES

- Designer Modularity/Versatility
- Permanent/Durable
- Economical/Low Life Cycle Costs
- Attractive Finish Options
- Abuse/Stain Resistant
- Interstitial Load Bearing Designs
- Contamination/Dust Free
- Integrates Services/Partitions
- Ease of Access
- Superior Acoustical Performance
  - -Sound Absorption NRC 0.60—0.95
  - -Sound Transmission Loss STC 33—45

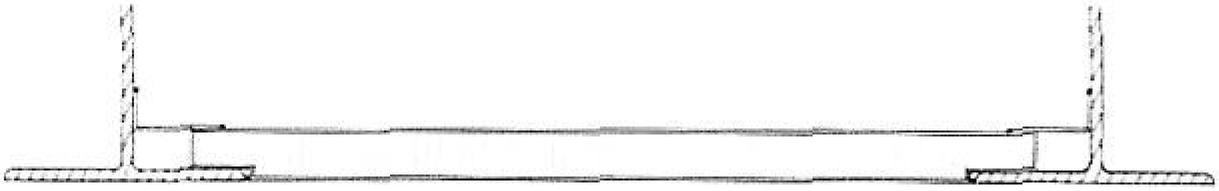
III CEILING SYSTEM

Detail below illustrates an unbacked panel which essentially provides sound absorptive performance only and backed panels which provide both sound absorption and transmission loss properties. In normal practice, these panel types would not be blended together.



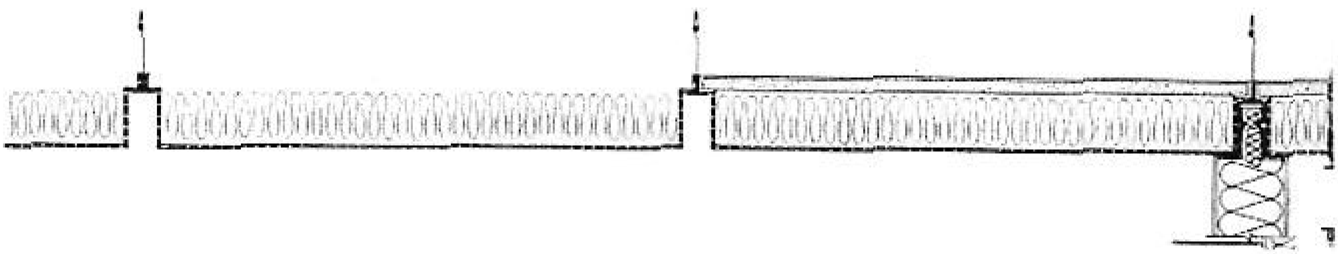
IV INTERSTITIAL SYSTEM

Detail below illustrates a typical interstitial load bearing panel supported on each side by continuous structural members. The Mark IV Interstitial System can also be furnished with a sound absorptive exposed surface providing acoustic properties similar to those shown for the Mark V System described below.



V CEILING SYSTEM

Detail below illustrates unbacked panels which essentially provide sound absorptive performance only and backed panels which provide both sound absorption and sound transmission loss properties. In normal practice, these panel types would not be blended together. The acoustic integration of the floor to ceiling partition detail is recommended for applications where good sound transmission loss characteristics are required between two offices or rooms.



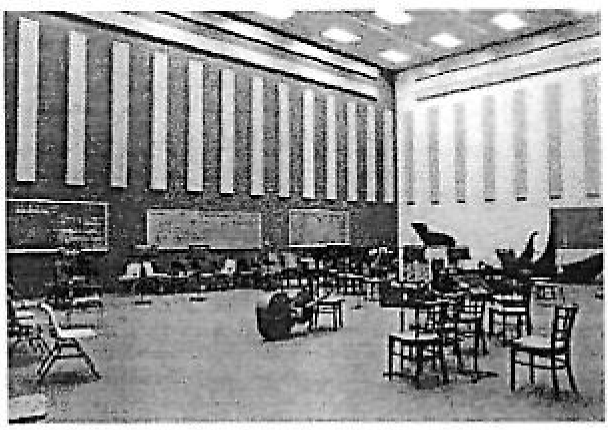
VARITONE™ SOUND ABSORPTION SYSTEMS
FOR NEW OR RENOVATED BUILDINGS

•DECORATIVE •CONTROL NOISE •ABUSE RESISTANT •CONTROL REVERBERATION

Industrial Acoustics Company's Varitone™ Sound Absorption Systems feature acoustically engineered, architecturally compatible, rectangular modules for attachment to walls or for suspension from ceilings of enclosed or semi-enclosed areas to reduce distracting echo/reverberation effects and thus create an acoustically softer, more pleasant ambience improving voice and audio communication.

Fabricated from 16-gauge (1.5 mm) to 22-gauge (0.76 mm) steel in standard widths, in modular lengths, and in thicknesses of two or four inches (51 or 102 mm), Varitone System modules containing acoustic/thermal fill have a higher degree of sound absorption, particularly in the hard-to-control low frequencies, than do light-weight-metal or fabric-covered designs. (We can supply the steel modules in heavier gauges for special applications.)

Fashioned with interior-design appeal and for long-service life, Varitone modules can be installed easily as individual units, in clusters, or in series. No matter where or how this IAC System is applied, the modules exhibit the best in visually attractive, abuse-resistant, sound absorptive properties to meet the most demanding requirements of consultants, architects, and owners.



Varitone I — Fabricated of rugged perforated steel in designer-attractive, abuse-resistant vinyl or painted finishes, the Varitone I module can be applied to the walls or ceilings of an area. Available in 2 in. (51mm) and 4 in. (102mm) thicknesses in standard widths of 18 in. (457mm) and 14 in. (356mm) respectively, and in modular lengths, *Varitone I provides high sound absorption and integrates readily with openings and services in both new or existing buildings.* Tables 1 and 2 on page 7 provide complete information on the acoustic properties of the Varitone I system. Information on how to use this data is provided on page 8. Request Bulletin 3.0701 for further details and specifications.

Varitone II — This acoustic baffle system provides sound absorption superior to conventional flat wall-mounted or ceiling systems. Available in 22 gauge (0.76mm) standard perforated or 26 gauge (0.5mm) microperforated galvanized steel, finished in durable paint or vinyl, the rugged Varitone II module can be easily installed in new or existing buildings.

During laboratory tests, it was determined that the degree of sound absorption achieved was influenced by the geometric array of the Varitone II modules. This data is shown in Table 1 on right. With this information, the most efficient array can be selected relative to the frequency of interest and the interface of the Varitone II modules with other building services such as lights and ventilation. Request case history Bulletin No. 3.1231 which describes how Varitone II was successfully applied to solve a difficult reverberation problem at the Washington DC Convention Center.

FEATURES/BENEFITS

•engineered sound absorption • reverberation control •noise reduction • modular flexibility • designer finishes •abuse, stain, and scratch resistant • ease of installation •wall/ceiling mounted • tamper and concealment resistant

APPLICATIONS

•auditoriums • gymnasiums • convention centers •concert halls • restaurants • houses of worship •schools • theaters • swimming pools • broadcast studios • jails and prisons • transit facilities • and other places of public accommodation

VARITONE I

TABLE 1 — VARITONE I SOUND ABSORPTION COEFFICIENTS

	Octave Band Center Frequency, Hz						
Module	125	250	500	1K	2K	4K	NRC*
2 in. (51 mm)	0.35	0.65	1.20	1.21	1.07	0.92	1.00
4 in. (102 mm)	0.97	1.39	1.34	1.29	1.19	1.01	1.30

*NRC stands for Noise Reduction Coefficient and is the average of the 250, 500, 1000, and 2000 Hz coefficients. It is a single number indicator of relative absorption values.

NOTE: These absorption measurements are based on ASTM C 423-84a, Type A mounting test procedure. Certified laboratory test reports available upon request.

TABLE 2 — ABSORPTION UNITS IN SABINS RELATED TO DIMENSIONS OF IAC VARITONE I MODULES

18 in. (457 mm) Wide — 2 in. (51 mm) Thick									14 in. (356 mm) Wide — 4 in. (102 mm) Thick							
Length in. (mm)	Area ft² (m²)	Frequency 125	250	500	1K	2K	4K	*Effective Average	Area ft² (m²)	Frequency 125	250	500	1K	2K	4K	*Effective Average
72 (1829)	9.00 (0.84)	3.2	5.9	10.8	10.9	9.6	8.3	9.0	7.00 (0.65)	6.6	9.7	9.4	9.0	[illegible]	7.1	9.1
84 (2134)	10.50 (0.98)	3.7	6.8	12.6	12.7	11.2	9.7	10.6	8.17 (0.76)	7.9	11.4	10.9	10.5	[illegible]	8.3	10.6
96 (2438)	12.00 (1.11)	4.2	7.6	14.4	14.5	12.8	11.0	12.0	9.30 (0.86)	9.0	12.9	12.5	12.0	[illegible]	9.4	12.1
108 (2743)	13.50 (1.25)	4.7	8.8	16.2	16.3	14.6	12.4	13.5	10.50 (0.98)	10.2	14.6	14.1	13.6	12.5	10.6	13.7
120 (3048)	15.00 (1.4[illegible])	5.3	9.8	18.0	18.2	16.1	13.8	15.0	11.70 ([illegible])	11.4	16.3	15.7	15.1	[illegible]	11.8	15.2

*Effective averages are based on NRC values.

NOTES ON LABORATORY TEST DATA — The sound absorption coefficients and Sabin content shown above are based upon laboratory tests for Varitone modules placed directly on the floor following Type A mounting procedure. The test modules were touching each other and contained no fill encasement or spacer. The sound absorptive results of these tests will vary as the test modules are separated from each other, the acoustic fill is encased in plastic, and an acoustic spacer is used between the fill and perforated metal. Certified laboratory tests for a great variety of options and configurations are available upon request. Contact IAC to determine the laboratory test data best suited to your particular application.

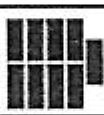
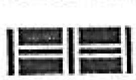
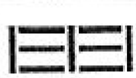
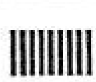
VARITONE II

Tests were conducted in the IAC Aero-Acoustic Laboratory for an architect and his client to investigate the sound absorptive characteristics of Varitone II. It was observed that performance varied with the placement and array of the units tested.

Some of this data is shown in table below. Awareness of this phenomenon is valuable in recommending solutions to noise and reverberation problems and in developing the most efficient baffle array and in the integration of the array with the building structure and services. **Contact IAC to determine how Varitone II can best be utilized to solve your problems.**

Note: Numbers greater than one are based on edge diffraction effects dependent on panel size and configuration including vertical and/or horizontal installation.

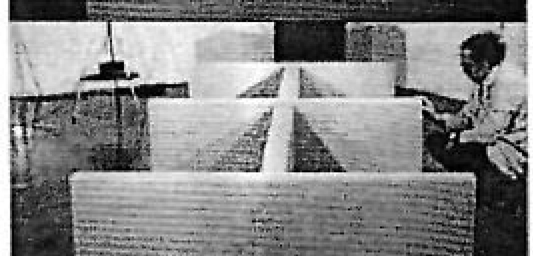
SOUND ABSORPTION OF 9 VARITONE II BAFFLES

Configurations				
Frequency	Sound Absorption Coefficients			
125	0.59	0.87	1.04	0.83
250	1.29	1.26	1.28	1.21
500	1.22	1.69	1.67	1.61
1000	1.07	1.46	1.57	1.44
2000	1.02	1.38	1.57	1.30
4000	0.97	1.41	1.53	1.35

Vertical Panel

Horizontal Panel

Notes:
1. All panels nominally 24 in. x 60 in. x 4 in. thick (610mm x 1524mm x 102mm)
2. Tests conducted in accordance with ASTM C 423



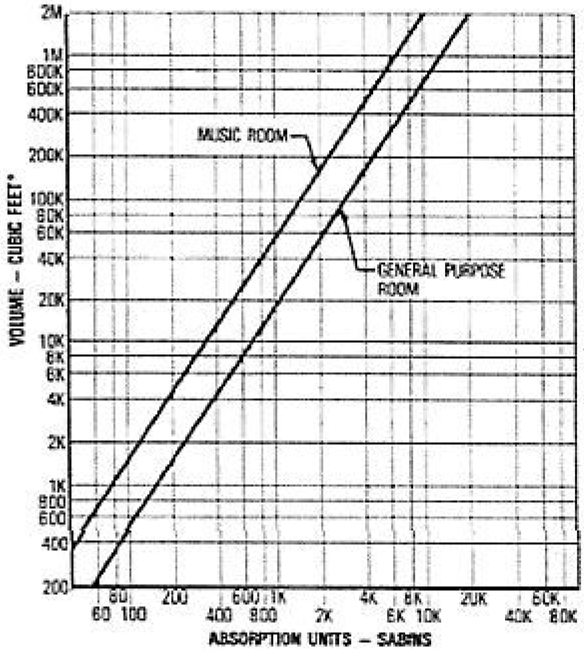
HOW TO USE VARITONE

The reverberation characteristics of interior spaces largely determine their acoustic environment assuming that the noise-reduction design of the rooms is well executed.

There are no ideal reverberation times. However, the quantity of absorptive units in Sabins shown in graph when added to a space results in obtaining commonly used satisfactory reverberation times. The graph is based on the assumption that the existing walls, ceiling and floor are acoustically reflective with a combined average sound absorption coefficient of approximately 0.075.

From the graph, find the required amount of sound absorption units (Sabins) to be added to the room. Use Table 2, page 7, which lists the number of Sabins for each size Varitone to calculate the number of modules needed to obtain the required amount of Sabins.

Allowance must be made for carpets, drapes and other sound absorptive materials, if any. Where low frequency "boominess" is a problem, use 4 in. (102mm) thick modules. Our architectural engineering department is available to assist you in these calculations.



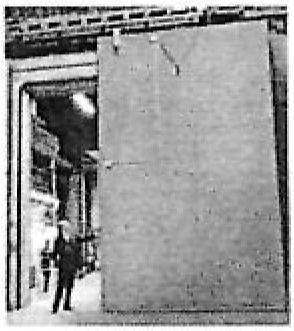
NOTE: M = million K = thousand

*To obtain volume in cubic meters multiply by 0.0283 or divide by 35.31

Industrial Acoustics Company *is the foremost designer and manufacturer of Noise Control Products and Systems. The company, founded in 1949, has engaged in acoustical-engineering research leading to a wide range of products from Medical Rooms that reduce sound levels to below the threshold of hearing and acoustically engineered Music Practice Rooms and Broadcast/Recording Studios to silencers and enclosures to control the roar of jet engines...one of the loudest of man-made noises.*

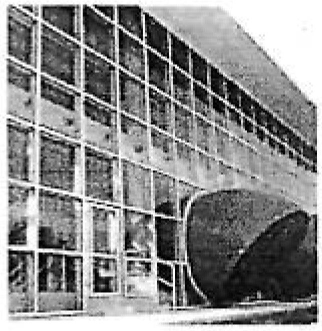
IAC designs and manufactures Anechoic Chambers and Reverberation Rooms for acoustic research and testing, soundproof doors, windows, ceilings, modular panels and silencers for almost every application including air conditioning and gas turbine systems. IAC highway and rail barriers reduce transportation noise and IAC sound-absorption systems help control noise levels in industrial and institutional buildings. At IAC the creation of new products for the needs of a fast-changing and increasingly noise-conscious society is a continuing process.

IAC ACCU-TONE™ STUDIOS



IAC NOISE-LOCK® DOORS

IAC MICRODYNE™ ANECHOIC CHAMBERS



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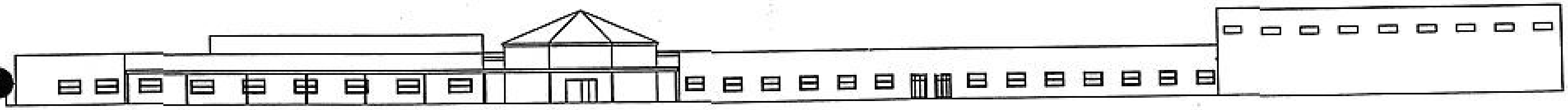

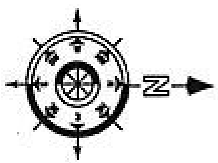

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DRAWING NUMBER

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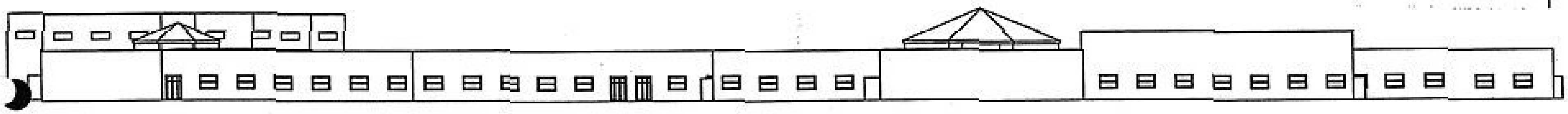

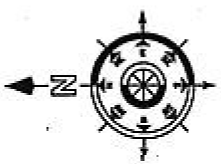

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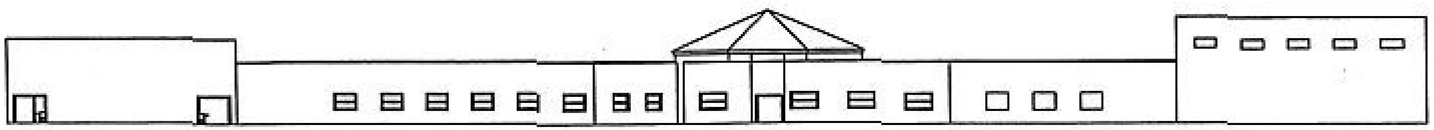

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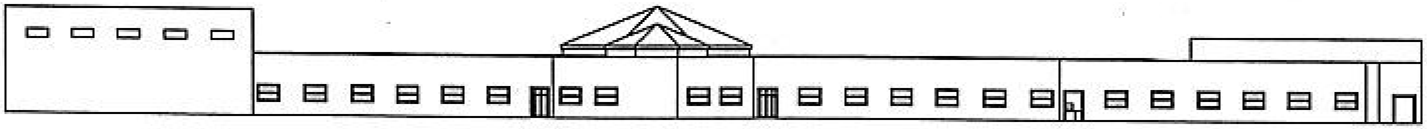

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SOUTH BUILDING ELEVATION

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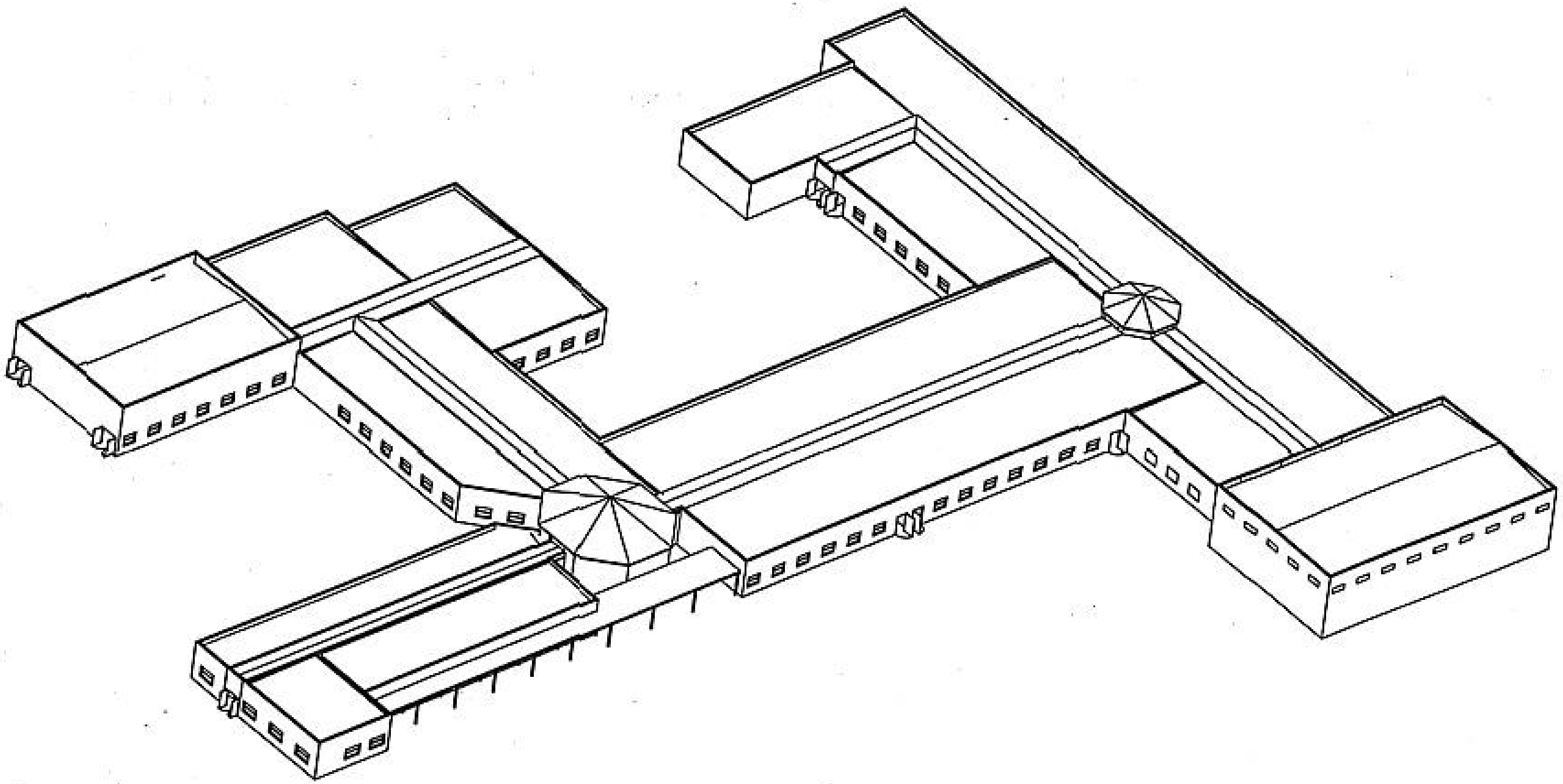
A-5



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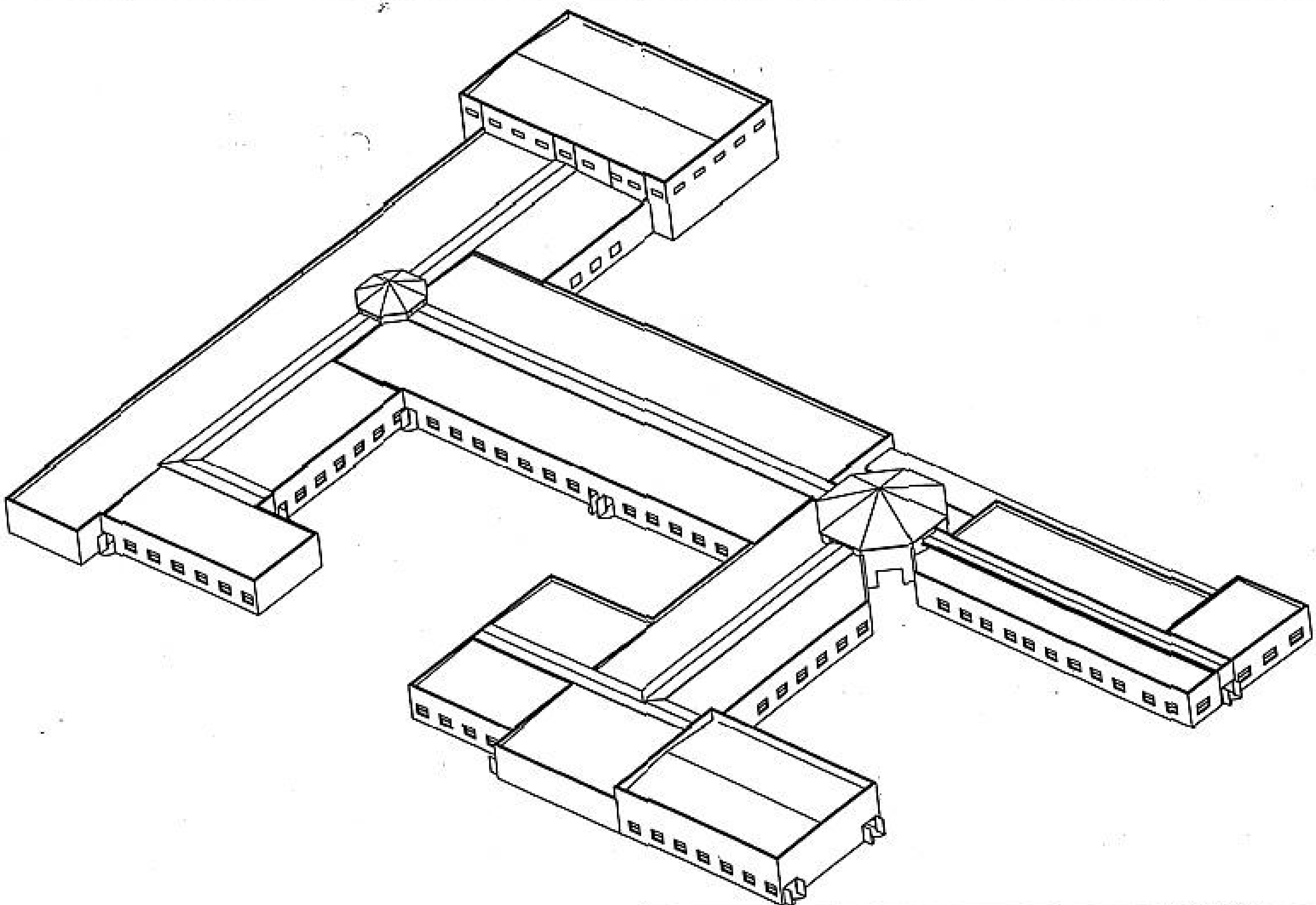

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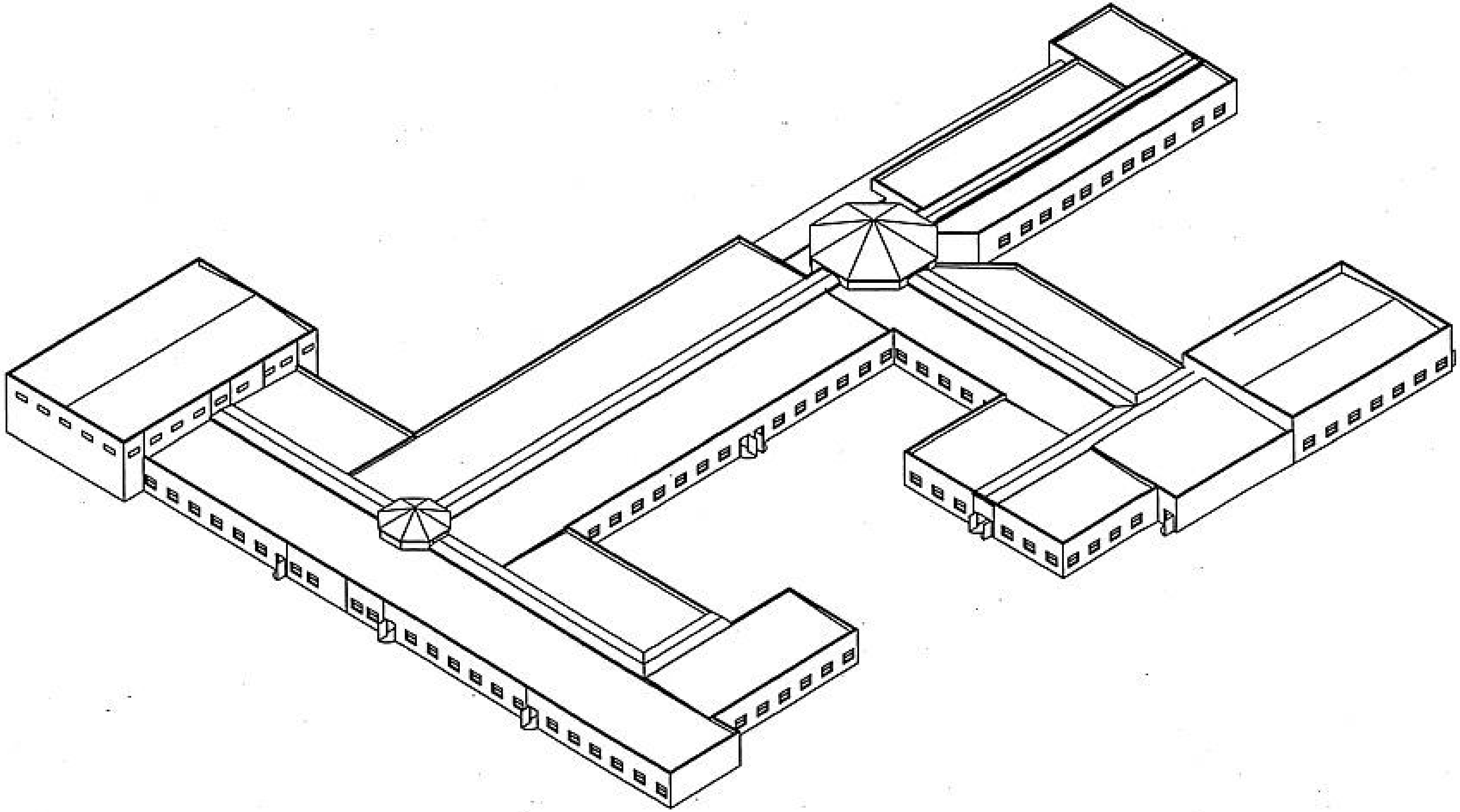

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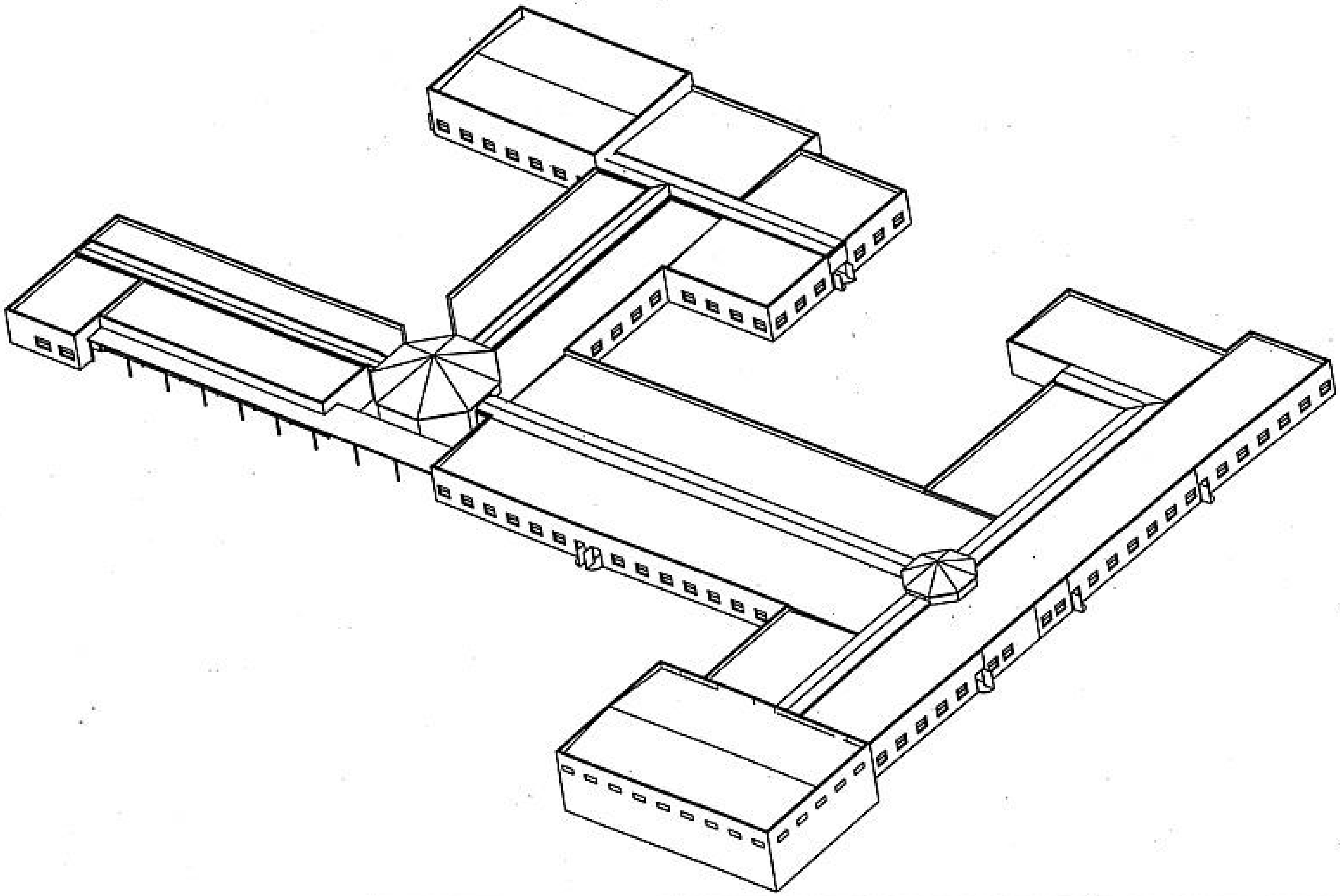

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DRAWING NUMBER

A-21

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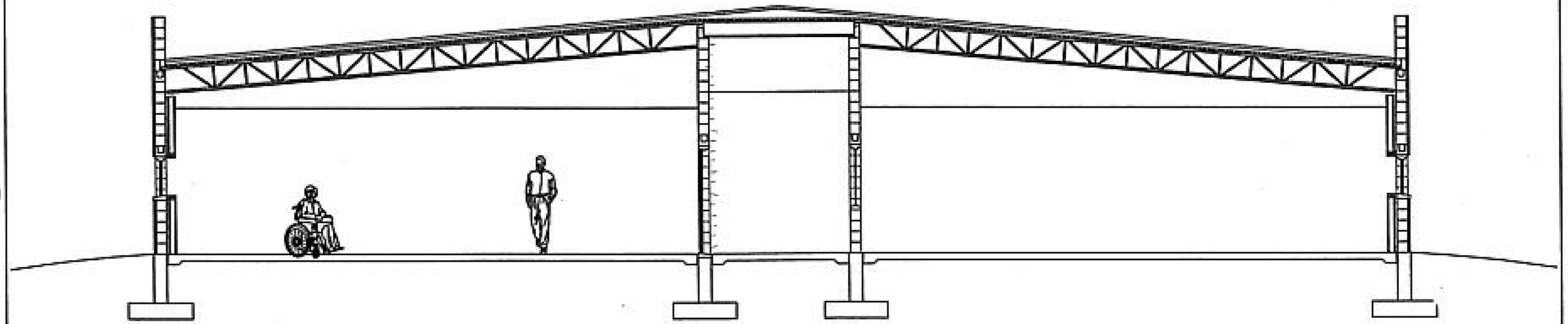

F B M Design	CLIENT ST MICHAELS ASSOCIATION FOR SPECIAL EDUCATION ST MICHAELS, AZ	DRAWING TITLE SECTION THRU CLASSROOMS	DRAWING NUMBER A-22

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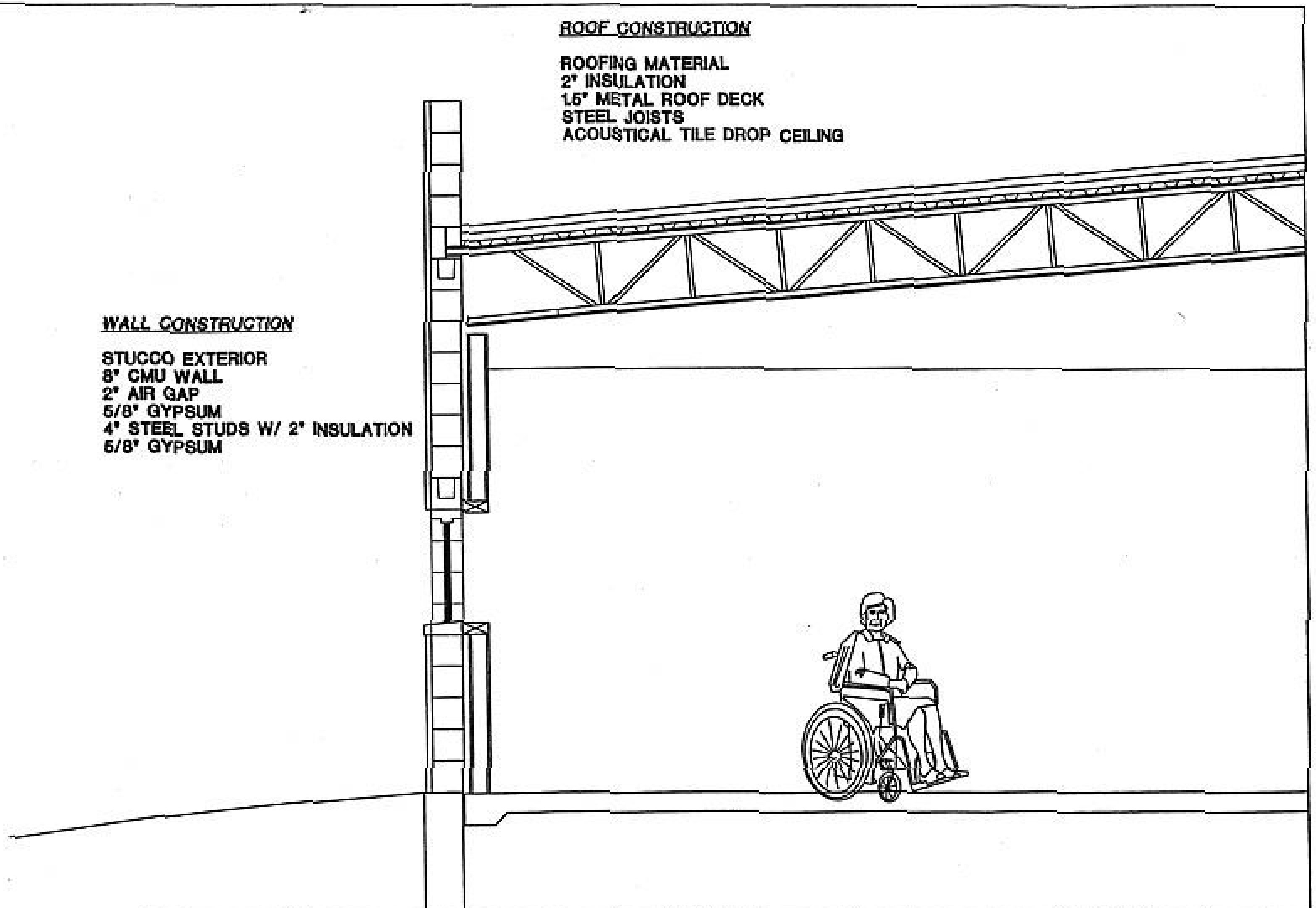


FBM Design	CLIENT ST MICHAELS ASSOCIATION FOR SPECIAL EDUCATION ST MICHAELS, AZ	DRAWING TITLE EXTERIOR CONSTRUCTION	DRAWING NUMBER A-23

Appendix D: Structural Appendix

The structural system proposed in the fall was promised to resist all lateral and gravity loads placed upon the structure.

Lateral Loads

The lateral loads are comprised of wind and seismic. The wind loads were calculated based upon the criteria set forth in the Uniform Building Code. The exact calculations follow in the subsequent pages. A wind pressure of 6.25 PSF was calculated for the windward walls and a suction of 3.875 PSF and 5.425 PSF were calculated for the leeward walls and roof, respectively. The seismic loads will be checked later after design when the overall weight of the building has been calculated.

Gravity Loads

The gravity loads on the roof include 6 PSF for roofing material, 0.8 PSF for insulation, and 2 PSF for the metal roof deck. A 10 PSF load was also added to the entire roof based on the approximate weight of the solar panels to be placed on the roof. The roof deck selected can withstand a span of about 5.5 feet when subjected to these loads.

System Selection

Three possible building alternatives for the wall system were explored. These were steel frame, concrete frame, masonry bearing wall with a precast concrete roof, and masonry bearing wall with a steel joist roof. Each of these was evaluated with an extensive list of criteria. Some of these criteria included:

- Availability of Materials: The St. Michaels campus is located in a very remote area so this criterion becomes a very important one. Most of the materials would be supplied from the nearest big city of Gallup, New Mexico. The city can probably supply most of these three materials since it appears to be a very industrious area, however masonry is probably the preferred system since it is the most likely material to be readily available.
- Availability of Skilled Workers: The area around St Michaels campus contains a very specific type of building. Although some of the buildings in the area are

built of steel, masonry is by far the prevailing construction method. This would lead FBM to believe that skilled workers are more available in masonry than any other building type.

- Material Costs: The upfront material cost is an important criterion because there is a very limited budget for construction. Steel is the most expensive building material in comparison. Concrete and Masonry have similar material costs.
- Transportability: The road back to the main campus is a very bumpy dirt road that cannot handle really heavy truckloads. Each of these materials can be very heavy to transport so transportability is not a really big factor. Concrete and Masonry would probably be the preferred systems because the amount that is carried in each truckload can be better controlled than steel.
- Ability to Deflect: The building material selected should be able to withstand minor deflections since the soil underneath the building is highly prone to differential settlement. Steel would be the most able to resist deflections, however if masonry is properly designed it could also pass.
- Span Versatility: In the case of the roof, the method of construction needs to be able to span a wide variety of distances from twenty-five feet to sixty feet. The roof will also need to be able to carry large loads from the mechanical units placed on the roof. Steel joists far surpass precast concrete in this criterion.
- Engineer's Preference: The engineer has experience is all three building types, so any of the building types pass this criterion. The engineer is however much more experienced in steel design than the other two wall types.
- Client's Preference: The client has a very good idea of the things that they would like to see in their building and also the materials they would like to see. They have expressed an interest in having a masonry bearing wall structure since that is what their current permanent buildings are constructed of.

Final System Selected

The final system selected was a masonry bearing wall structure with a steel joist roof. This system was selected because it fits all of the major criteria for the building. Concrete frame was clearly eliminated because it is not used readily in the area, not very able to deflect, cannot span large distances easily, and is difficult to design and detail. The masonry-bearing wall with a precast concrete roof was eliminated because it is not able to span long distances easily and it would be difficult to transport down the bumpy road to the site. Steel was eliminated because of the large construction expense and the availability of skilled workers and materials.

Wall Lateral Support Requirements

The minimum lateral support requirements (l/t) are given by Table 21-O in the 1997 Uniform Building Code.

Construction	Maximum l/t or h/t
Bearing Walls	
Solid or Solid Grouted	20
All other	18
Nonbearing Walls	
Exterior	18
Interior	36

Lateral loads were resisted through the use of a combination of pilasters and cross walls. Several different types of walls occur in the building and as a result they have separate requirements.

1. 8" Thick Hollow Bearing Walls (l/t = 18):

   Maximum Laterally Unsupported Length = 18(8) = 12'-0"

2. 8" Thick Nonbearing Exterior Walls (l/t = 18):

   Maximum Laterally Unsupported Length = 18(8) = 12'-0"

3. 8" Thick Nonbearing Interior Walls (l/t = 36):

   Maximum Laterally Unsupported Length = 36(8) = 24'-0"

4. 12" Thick Hollow Bearing Walls (l/t = 18):

   Maximum Laterally Unsupported Length = 18(12) = 18'-0"

5. 12" Thick Nonbearing Exterior Walls (l/t = 18):

   Maximum Laterally Unsupported Length = 18(12) = 18'-0"

Control Joints

Control joints will be placed in the masonry where the pilasters meet the main wall. A ½" control joint has the ability to span a maximum of twelve feet and so the span between each on the pilasters should be adequate enough. The sealant used is specified at a ±25% sealant movement and is supplied by Master Builders. See calculations and cut sheets for the control joints later in this appendix.

Total Roof Load Calculations

The factored roof load value will be calculated using the Load and Resistance Factor Design Method. The load will then be used to calculate the joist and beam sizes needed to adequately support the roof structure.

Load Description	Weight (psf)
Dead Loads	
Built-up Roofing	6
2" Rigid Insulation	0.8
½" Metal Deck (20 Gage)	2.1
Solar Panels	10
TOTAL (D)	19
Roof Live Load (L_r)	20
Snow Load (S)	10
Wind Uplift Load (W)	5.5

LRFD Load Combinations:

1. $1.4D = 1.4(19) = 26.6$ psf
2. $1.2D + 0.5L_r = 1.2(19) + 0.5(20) = 32.8$ psf
3. $1.2D + 1.6L_r + 0.8W = 1.2(19) + 1.6(20) + 0.8(5.5) = 59.2$ psf
4. $1.2D + 1.3W + 0.5L_r = 1.2(19) + 1.3(5.5) + 0.5(20) = 40.0$ psf
5. $1.2D + 0.2S = 1.2(19) + 0.2(10) = 24.8$ psf
6. $0.9D - 1.3W = 0.9(19) - 1.3(5.5) = 10.0$ psf

The highest value of these load combinations is taken as the roof load; therefore the total factored roof load is 59.2 pounds per square foot.

Joist Design

KCS joists were used for spans less than 50 feet, and LH joists were used in the gymnasium where the span is greater than 50 feet. KCS joists will be used because general locations and weights of the solar panels and mechanical equipment on the roof are known. The KCS joists are so named because they are constant shear joists. They are capable of carrying the same value of shear across their entire length. As long as the point loads do not surpass the maximum shear specified on the design sheets, the joist will not fail. Refer to joist calculations and the joist plan later in this appendix. KCS joists are designed by calculating the ultimate shear and moment that the joist can hold. The KCS joist load table is then consulted to find the least size of joist that corresponds to the ultimate load and shear. This joist then needs to be checked for the specified deflection criteria of L/240. The final joist designs are between 10 and 20 inches deep.

Roof Deck

The roof will be covered by a United Steel Deck, Inc. Type "B" 20 gage wide rib deck. The USD catalog gives a maximum span between supports for this type of deck at 7'-6". This span will support up to 65 pounds per square foot and maintains the specified L/240 deflection criteria. See copy of the selection chart later in this appendix.

Skylights

The roof over the top of the atriums will be a skylight system made by Kalwall. The skylights will either be designed in an octagon shape or a pyramid shape. Two of each of these skylights will be needed. The base of the skylight will rest on steel beams and masonry walls depending on the location. Structural skylights may also be incorporated in to the roof of the cafeteria and gymnasium buildings. See cut sheets and details of the skylight system later in this appendix.

Steel Canopy Design

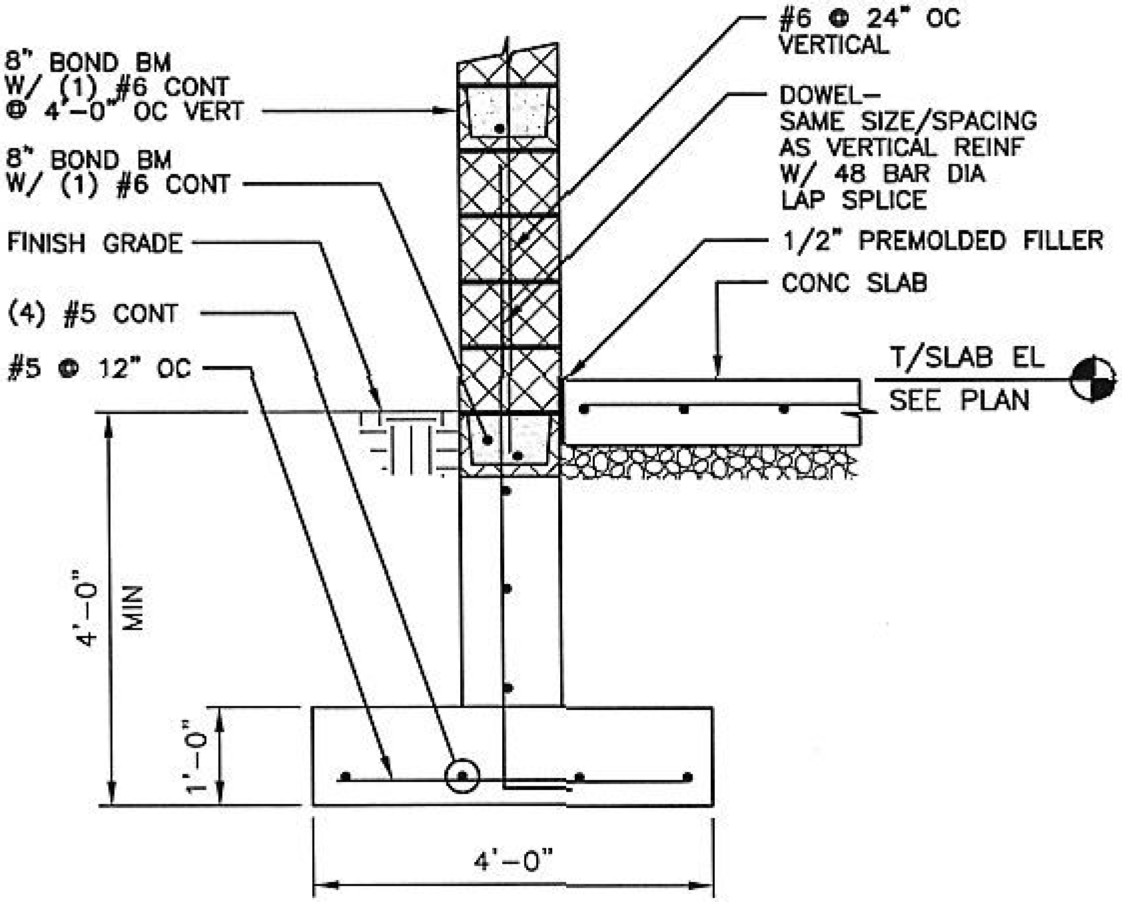
The front canopy over the entrance to the building is constructed of hollow stainless steel columns supporting a wide-flanged frame roof. The design of the canopy is shown later in this appendix.

References

Fortieth Edition Standard Specifications Load Tables and Weight Tables for Steel Joist and Joist Girders. Steel Joist Institute, 1994.

Uniform Building Code.

United Steel Deck design Manual and Catalog of Products. 1997.



PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE:	TYPICAL WALL SECTION

FBM *Design*

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
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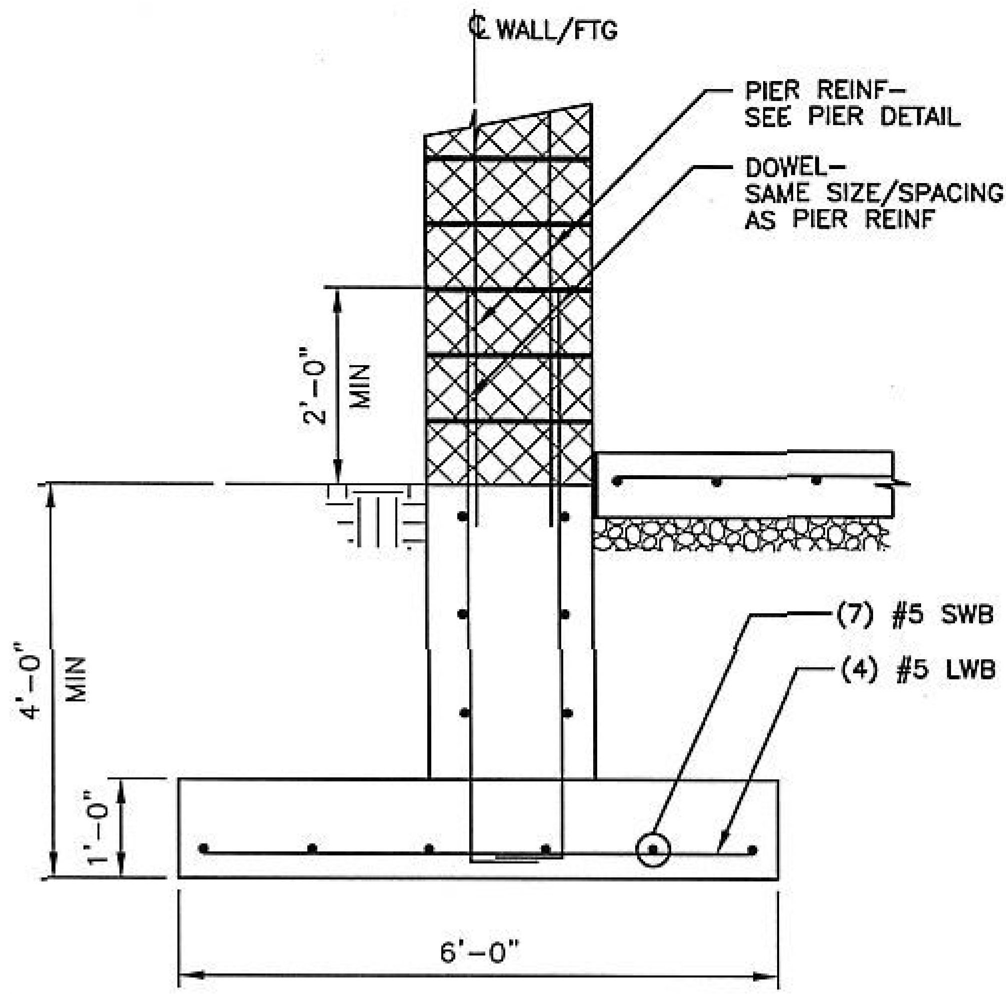

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE: TYPICAL WALL SECTION AT PILASTER

F B M Design

ISSUE DATE	05–25–01	ENGINEER	JTR	DRAWING No.
LAST REV	–	DESIGNER	JTR	
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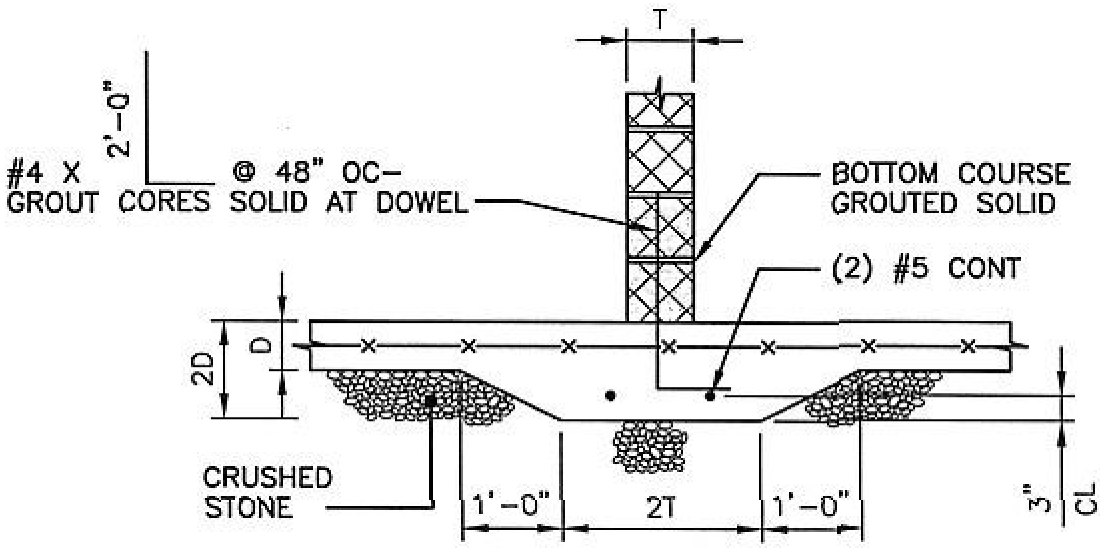

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE:	TYPICAL THICKENED SLAB BELOW SHEAR WALLS

FBM Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
LAST REV	–	DESIGNER	JTR	S-3
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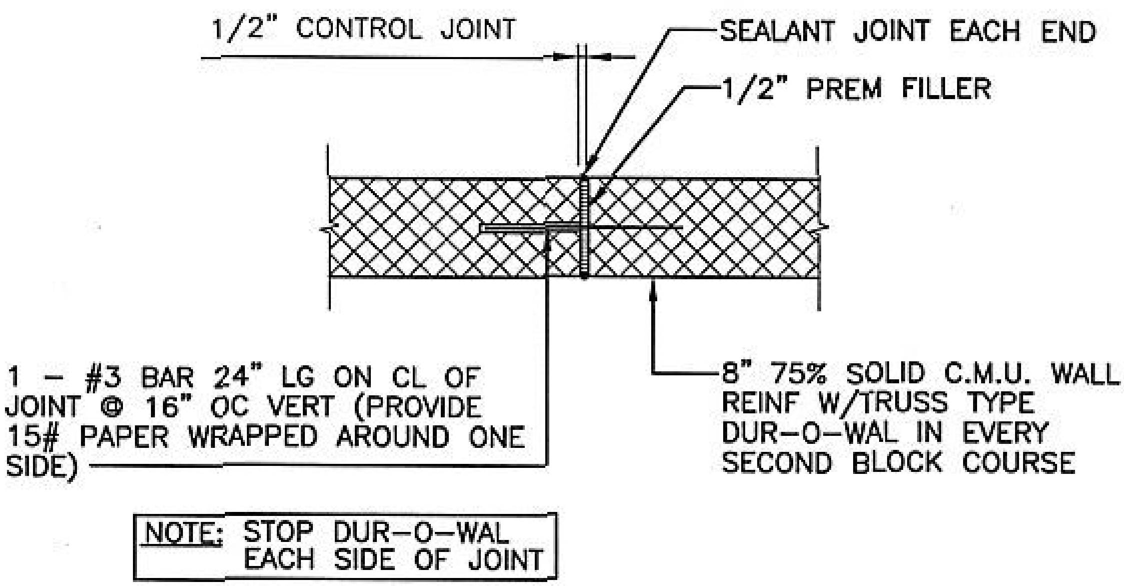

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE:	TYPICAL MASONRY CONTROL JOINT

FBM Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
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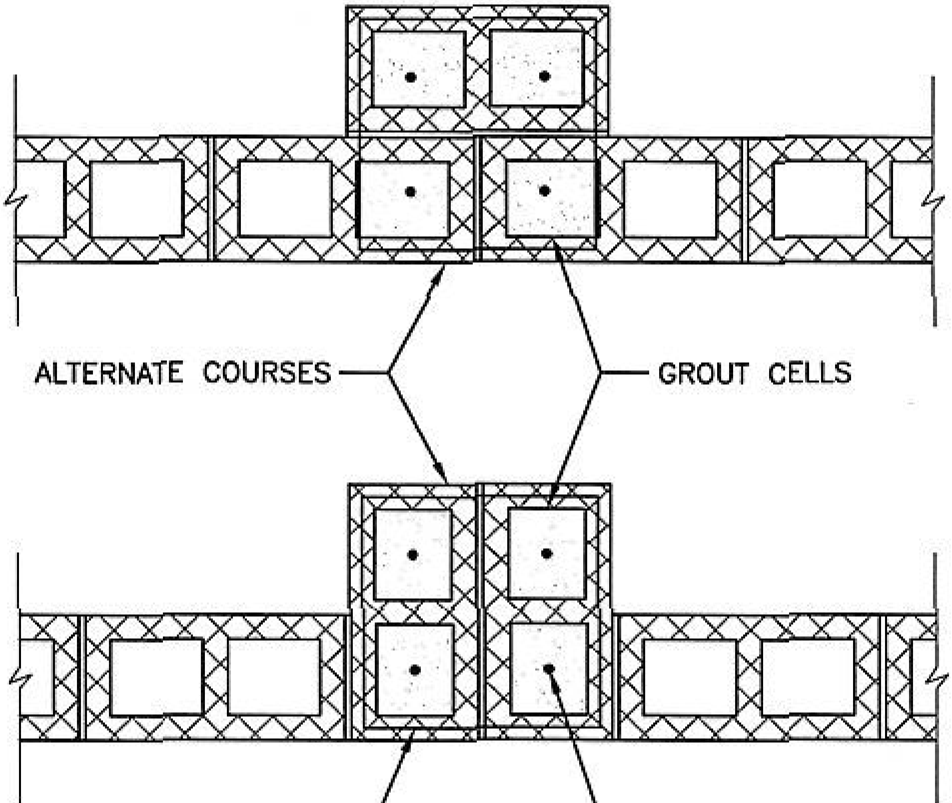

PLAN

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE:	TYPICAL 8" CMU PILASTER

FBM Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
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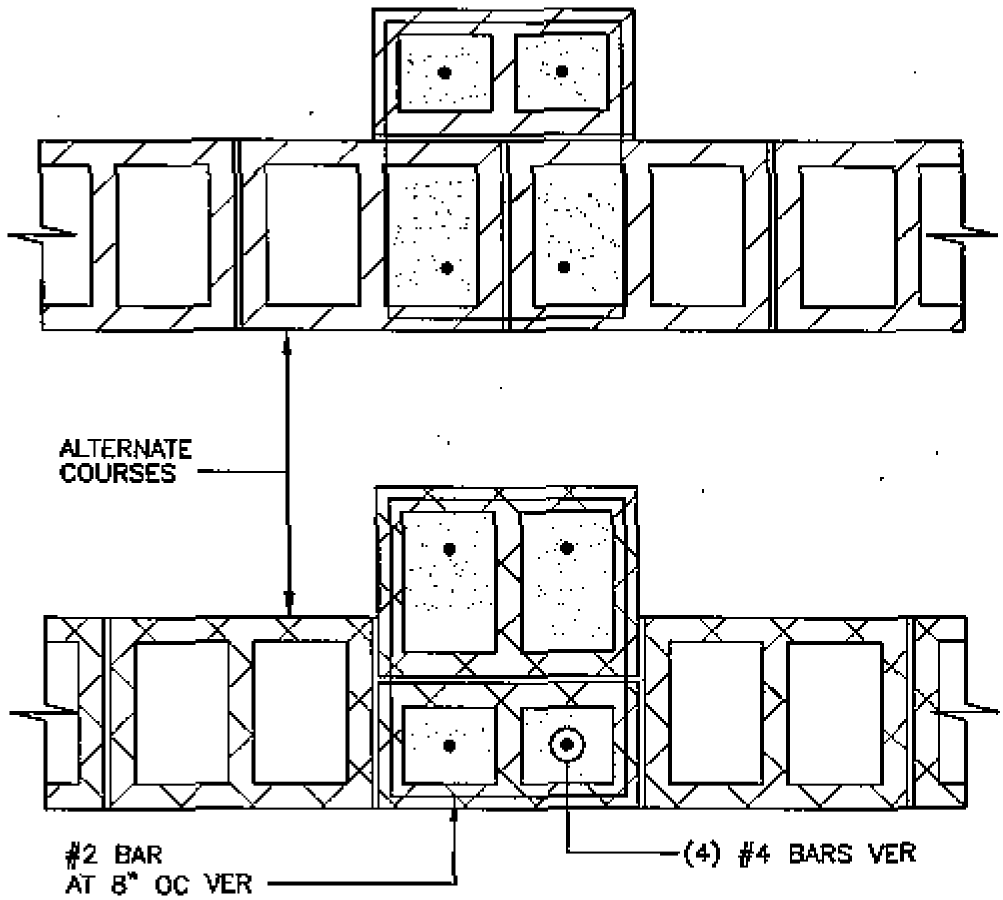

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE: St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE: TYPICAL 12" CMU PILASTER

F B M Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
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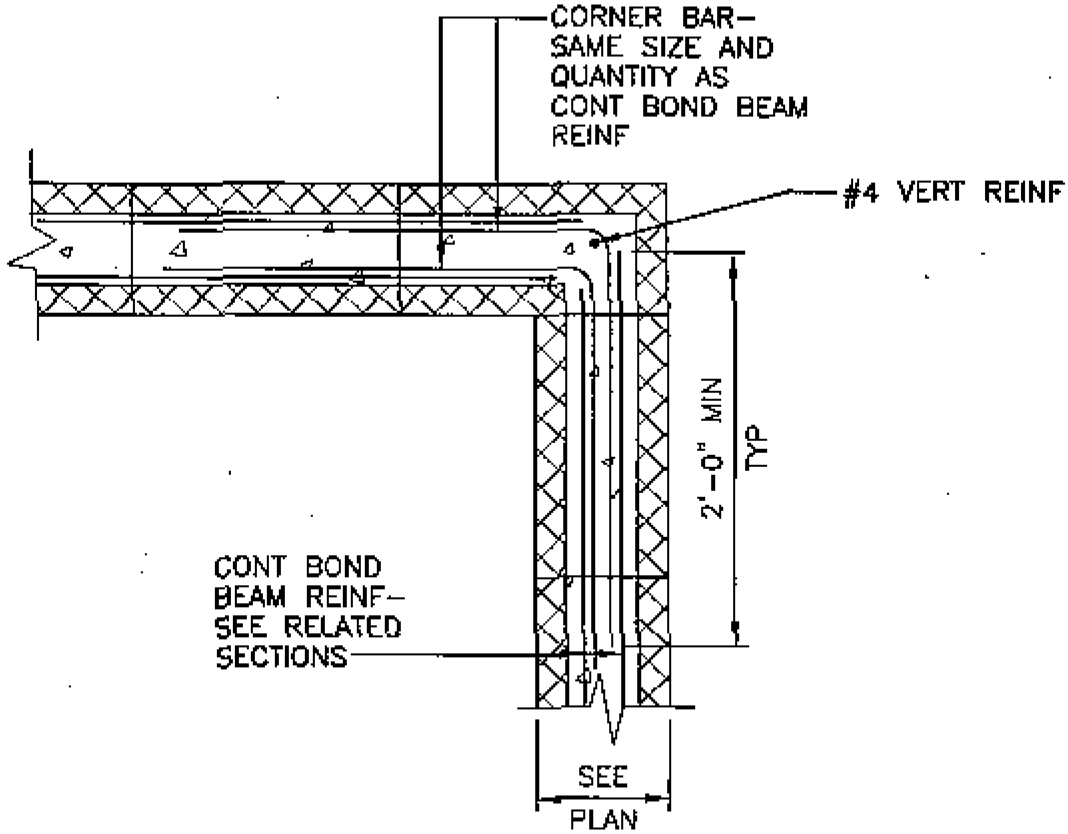

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE: St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE: TYPICAL CORNER BOND BEAM

FBM Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
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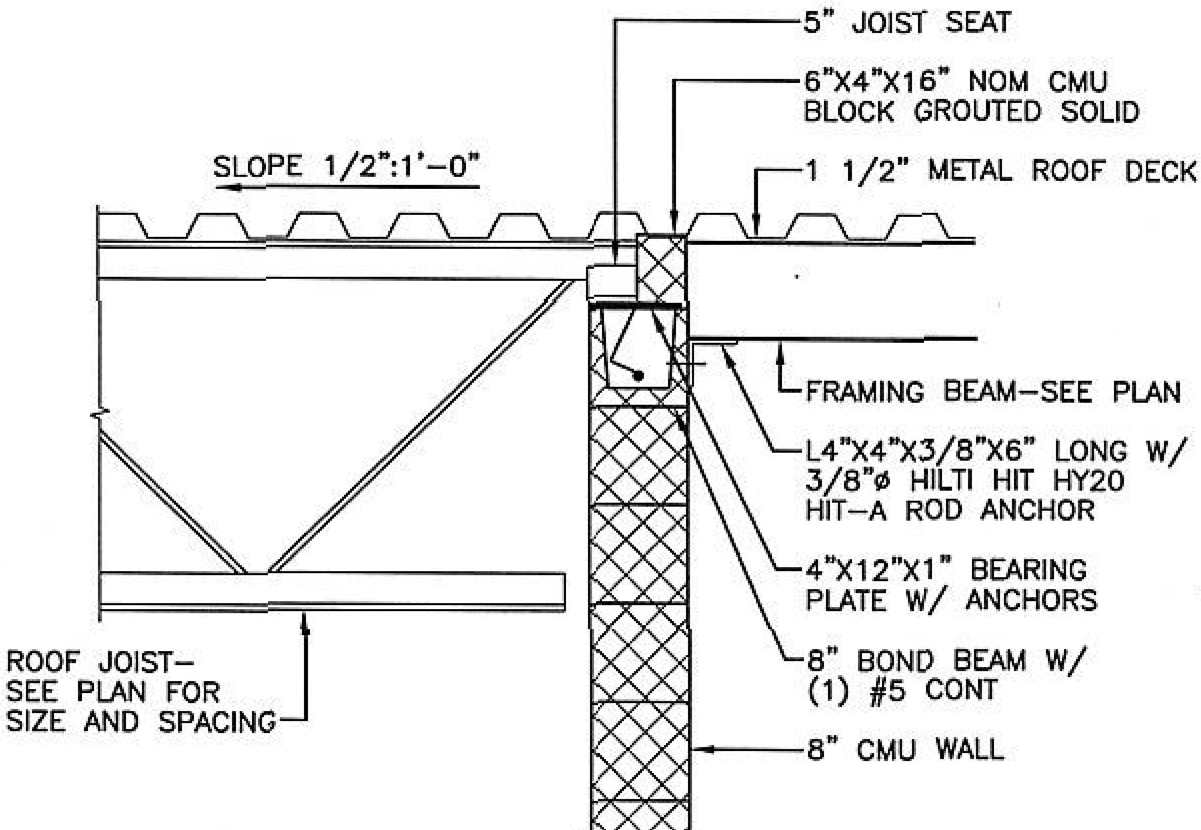

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE:	WALL SECTION AT HALLWAY

FBM Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
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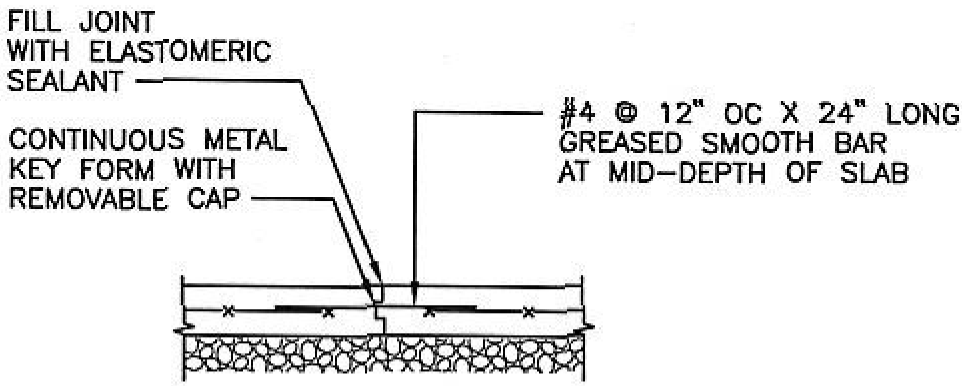

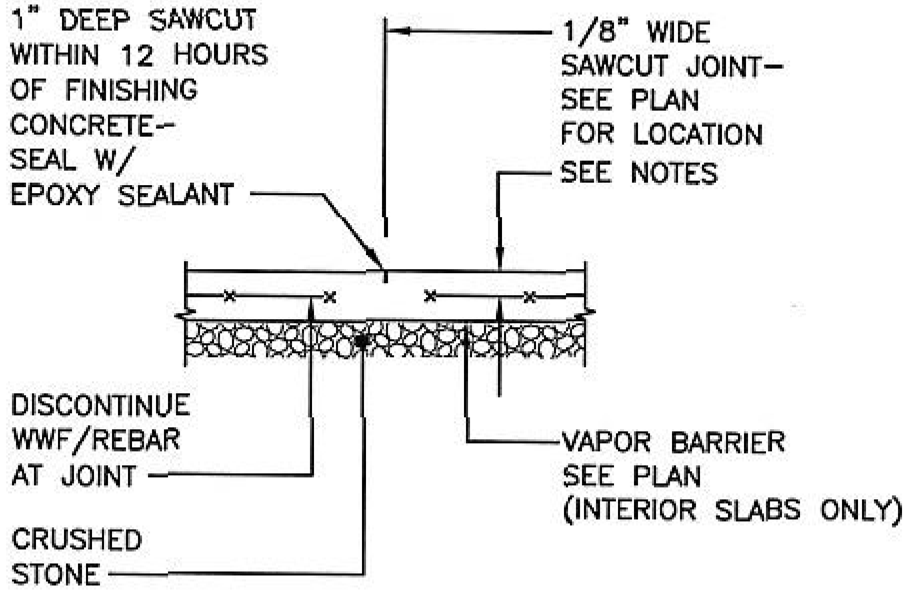

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE: TYPICAL CJ/CONST JT DETAILS

FBM Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
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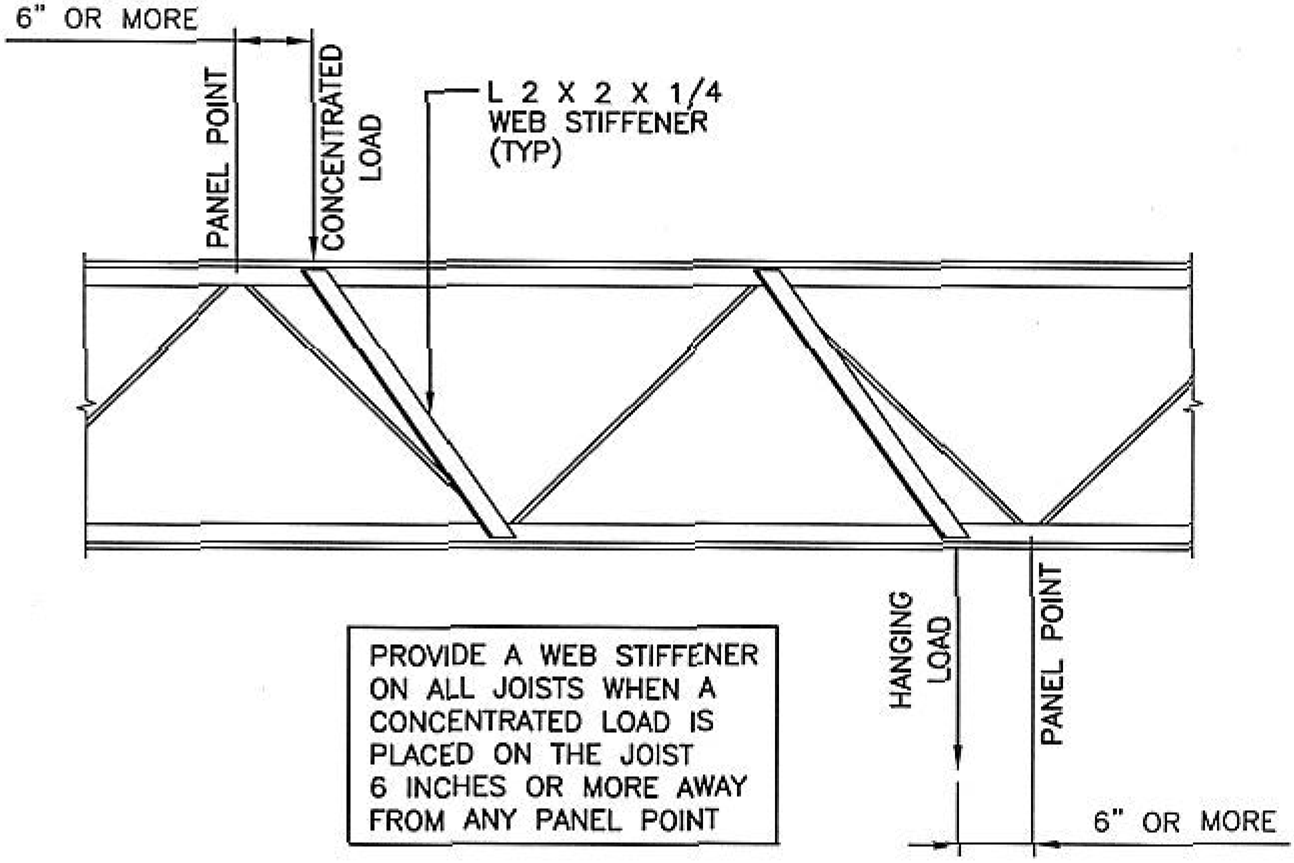

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CLIENT/ PROJECT TITLE:	St MICHAELS ASSOCIATION FOR SPECIAL EDUCATION	DRAWING TITLE:	TYPICAL WEB STIFFENER

FBM Design

ISSUE DATE	05-25-01	ENGINEER	JTR	DRAWING No.
LAST REV	-	DESIGNER	JTR	S-10
IPS PROJ#	CAE08/00-01	DRAWN BY	JTR	
CAD FILE#	S-10	SCALE	3/4"=1'-0"	

CONTROL
JOINT
CALCS

Master Builders Technologies

MASTERFLEX® 700

High performance, elastomeric joint sealant, (gun and pouring grades)

Description

MASTERFLEX 700 is a high grade, polysulphide based sealant possessing outstanding resistance to deterioration due to weathering, ozone, ultra-violet light and attack by chemicals present in industrial atmospheres. It has the ability to withstand repeated cycles of compression and extension over a wide temperature range, and has excellent adhesion properties to all materials commonly employed in building and construction work.

MASTERFLEX 700 can be supplied in pouring and gun grade for sealing horizontal and vertical joints where movement is expected, or where the performance specification is too rigorous for most common mastic and joint sealers. It is ideal for use in expansion joints in reinforced concrete structures such as bridges, reservoirs, water treatment works, sea walls and roads, etc. It can also be used in floors subject to heavy usage where a high resistance to damage is required.

Typical properties

Colour:	grey
Solid content %:	> 99%
Viscosity:	thixotropic paste
Tack free at 20°C:	24 hours
Staining:	none
Slump gun grade:	nil
Resistance to ozone:	non-crack
Hardness shore A:	25
Operating temperature:	-30°C to 90°C
Recommended Movement:	transverse ±25% M.A.F. (Movement Accommodation Factor)

Packaging

Gun Grade: 3 litre sealed containers

Pouring Grade: 3 litre sealed containers

Standards

ASTM C920 - 79

BS 4254 - 83

BS 5212 - 90

WRC For use in Potable Water (Grey)

US Federal Specification

TT-S-00227E

SS-S-200D

Typical set and cure times

Property	5°C	10°C	25°C	40°C
Pot life	24 hrs	18 hrs	2 hrs	1 hr
Initial set	5 days	72 hrs	24 hrs	5 hrs
Full cure	8 wks	5 wks	2 wks	7 days

Joint size

Joint size may range from a minimum of 5mm to a maximum of 50mm wide. Joints with cyclic movements should have a width:depth ratio 2:1 and designed so total movement does not exceed the 25% M.A.F. related to the joint width. Sealant depth shall not exceed joint width.

Minimum sealant depth recommended:

- 5mm for metals, glass and other impervious surfaces.
- 10mm for all porous surfaces.
- 20mm for joints exposed to hydrostatic pressures.
- 5mm below flush for joints exposed to traffic.

Application procedure

Joint preparation surface treatment:

Concrete & Masonry	Surfaces must be clean and dry. Wire brush thoroughly and remove dust and all contaminants.
Metals	Remove any corrosion or millscale by grit or shotblast, wirebrush, grinder or chemical remover. De-grease the surfaces with clean cloths soaked in oil-free cleansing solvent.
Wood (bare)	Wood surfaces must be clean

	and dry, cut back or abrade where necessary to sound timber.
Glass and glazed materials	Thoroughly clean the surfaces with clean cloths soaked in oil-free cleansing solvent.
Coating surfaces	Coating should be removed and the surfaces treated as above.

Where required, a bond breaking tape should be applied before priming.

Priming:

The correct primer must always be used.

Surface application:

Porous surfaces (such as concrete and masonry)	MASTERFLEX PRIMER NO 1
Non-porous surfaces (such as metals, glass and glazed surfaces)	MASTERFLEX PRIMER NO 2

- Application of primer should not be carried out below 4°C.
- A single coat of primer should be applied by brush in accordance with the instructions on the primer tins. The primer must be allowed to dry to a tack free state before applying MASTERFLEX 700.
- MASTERFLEX 700 should be applied within 3 hours of primer, otherwise repriming will be necessary.

Application temperatures:

MASTERFLEX 700 should be applied when the ambient temperature is between 4°C and 50°C. When the temperature is below 10°C storage at room temperature for several hours will ease mixing and application.

Mixing MASTERFLEX 700:

- Mix and use one complete unit at a time. Do not sub-divide.
- Gun grade is supplied in a single can. Pouring grade is supplied in separate tins with the curing agent contained in a smaller tin.
- Mix for 5 - 10 minutes using a suitable paddle fitted to a 500 rpm electric drill moving the paddle completely through the mass of the material. The sides and base of the container should be periodically scraped down with a palette knife to ensure all of the curing agent is completely blended with the base compound.
- Failure to completely disperse curing agent throughout the base compound will result in uncured sealant. Once mixed MASTERFLEX 700 should be used immediately.

Application:

- MASTERFLEX 700 is formulated to be applied using a sealant gun but may be applied by trowel if required.
- Sealant guns are fitted with conical nozzles which can be cut to suit the joint width.

- The sealant should be gunned into the joint using an even trigger pressure, cleaning the nozzle occasionally to avoid contamination. Deep joints should be filled in two or more runs, to prevent air entrapment.

- Once the sealant has been applied, a small timber spatula, soaked in soapy water, should be used to compact the sealant into the joints and to achieve a smooth polished finish. Any masking tape which has been applied should be removed before the sealant cures.

- Mixing and application equipment should be cleaned immediately.

Coverage

MASTERFLEX 700 (length of joint in metres filled per 1 litre of material)

Depth of joint	Width of joint mm				
mm	10	15	20	25	30
10	10	6.7	5	4	3.33
15		4.45	3.33	2.67	2.23
20			2.5	2	1.67
25				1.6	1.33

Storage

Store under cover out of direct sunlight and protect from extremes of temperature. In tropical climates the product must be stored in an air conditioned environment. Shelf life is at least 12 months when stored between 5°C and 35°C.

Safety precautions

The components and mixed sealant should not be left in contact with skin for prolonged periods. Gloves should be worn and the use of a barrier cream is strongly recommended. Solvent must not be used for cleaning the hands. Use an industrial cleaner and wash with soap and water. For further information including disposal instructions refer to the Material Safety Data Sheet.

Note

Field service, where provided, does not constitute supervisory responsibility. For additional information contact your local MBT representative.

MBT reserves the right to have the true cause of any difficulty determined by accepted test methods.

Quality and care

All products originating from MBT's Dubai, UAE facility are manufactured under a management system independently certified to conform to the requirements of the quality, environmental and occupational health & safety standards ISO 9000, ISO 14001 and OHSAS 18001.

11/93 MBT-ME revised 01/2001

Wind Load Calculations

Wind Pressure:

$P = C_e C_q q_s I_w$

$C_e = 0.62$ [<15' wall, exposure level B]

$I_w = 1.0$ [Category 3 occupancy]

$q_s = 12.6$ psf [Basic wind speed of 70MPH]

$C_q = 0.8$ inward (windward wall)

0.5 outward (leeward wall)

0.7 outward (roof)

windward wall:

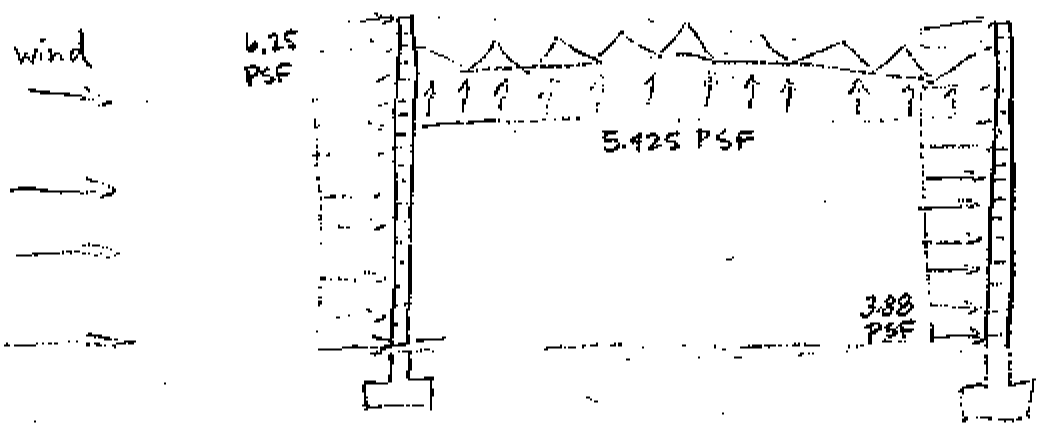
$P = (0.62)(0.8)(12.6\text{ PSF})(1.0) = 6.25$ PSF

leeward wall:

$P = (0.62)(0.5)(12.5\text{ PSF})(1.0) = 3.88$ PSF

roof:

$P = (0.62)(0.7)(12.5\text{ PSF})(1.0) = 5.425$ PSF



Control Joint Calculations

$X = 75$ (High Heat Capacity Material)
$S = 0.60$ (Medium / Light Buff Bricks)
$T_a = 94\ °F$
$T_w = 12\ °F$
$C_t = 5.2 \times 10^{-6}$ in/in/°F (Normal Weight Masonry)
$S_m = 25$
$L = 12'-0"$ (trial - spacing of pilasters)

$$T_s = T_a + XS = 94 + 75(0.6) = 139\ °F$$
$$\Delta T = T_s - T_w = 139 - 12 = 127\ °F$$
$$M_t = C_t \Delta T L = (5.2 \times 10^{-6})(127)(144) = 0.951 \text{ in}$$
$$J_t = \left(\frac{100}{0.8 S_m}\right) M_t = \left(\frac{100}{0.8(25)}\right) 0.0951 = 0.475 \text{ in}$$
$$J_m = C_m L = (-0.0006)(144) = -0.0864 \text{ in}$$
$$\text{Joint Width} = 0.475 - 0.0864 + J_c = \boxed{0.5 \text{ in}}$$

Long Span Joist Design

Cafeteria: Span = 56'-0"

$$Load = \frac{(6.67)(59.2)}{0.9(1.65)} = 265.8 \text{ lbs/ft}$$

Choose: **32 LH 07**

Check Δ: $I = 26.767(162)(56.67)^3(10)^{-6} = 789 \text{ in}^4$

$$\Delta = \frac{5\left(265.8 + \frac{1.2(16)}{0.9(1.65)}\right)(56(12))^4}{384(29\times10^6)(789)(12)} = 2.7 \text{ in } (L/249) \text{ (OK)}$$

Kitchen: Span: 44.5 ft

$$Load = \frac{6(59.2)}{0.9(1.65)} = 239.2$$

Choose: 24LH04

Check Δ: $I = 301 \text{ in}^4$

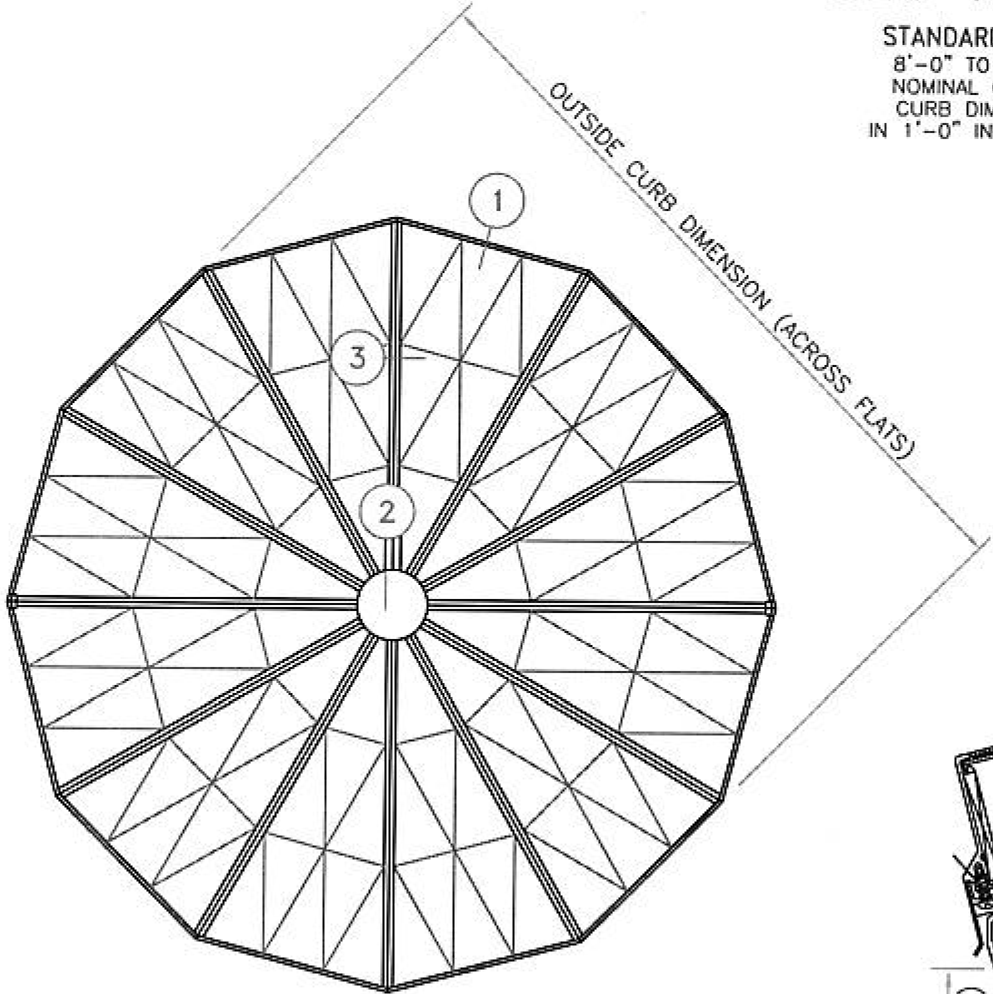
$\Delta = 2.51 \text{ in } (L/212)$ NO GOOD

Use **24LH05**

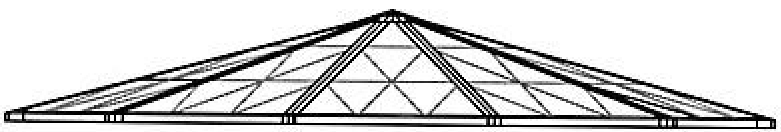
Gymnasium: Needs to resist weight of KCS Joists

GEO ROOFS

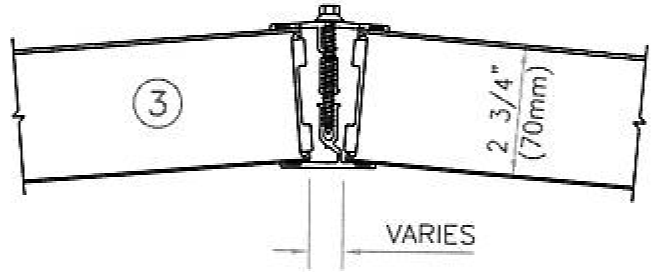
STANDARD SIZES
8'-0" TO 28'-0"
NOMINAL OUTSIDE
CURB DIMENSION
IN 1'-0" INCREMENTS

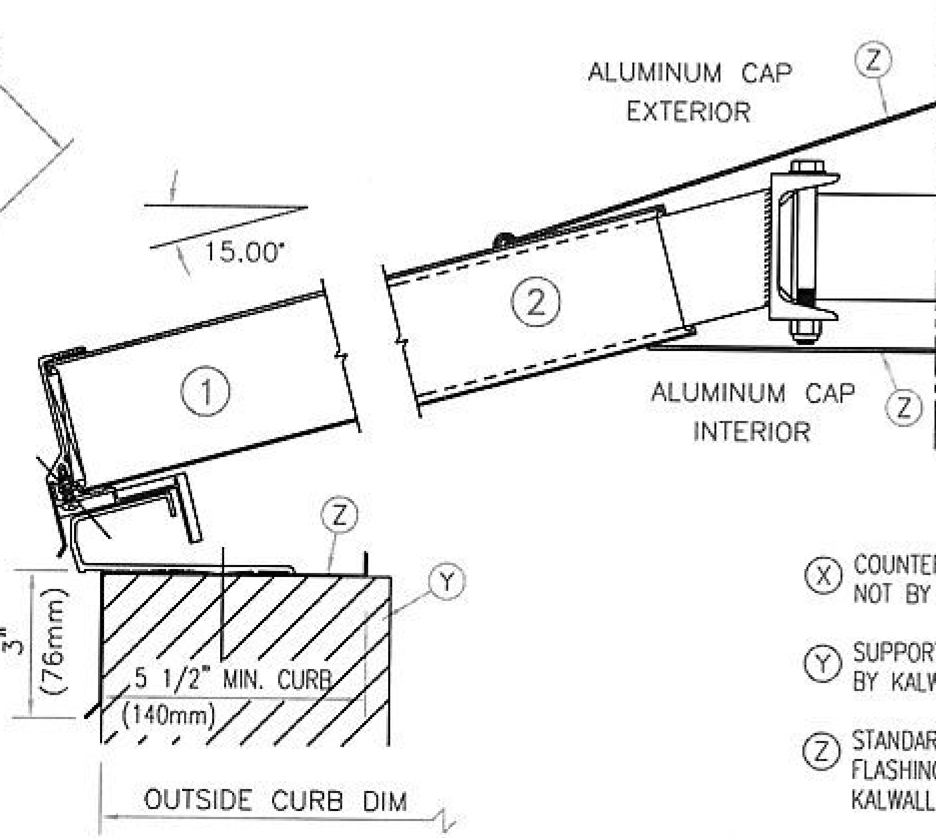


GEO ROOF PLAN VIEW



ELEVATION



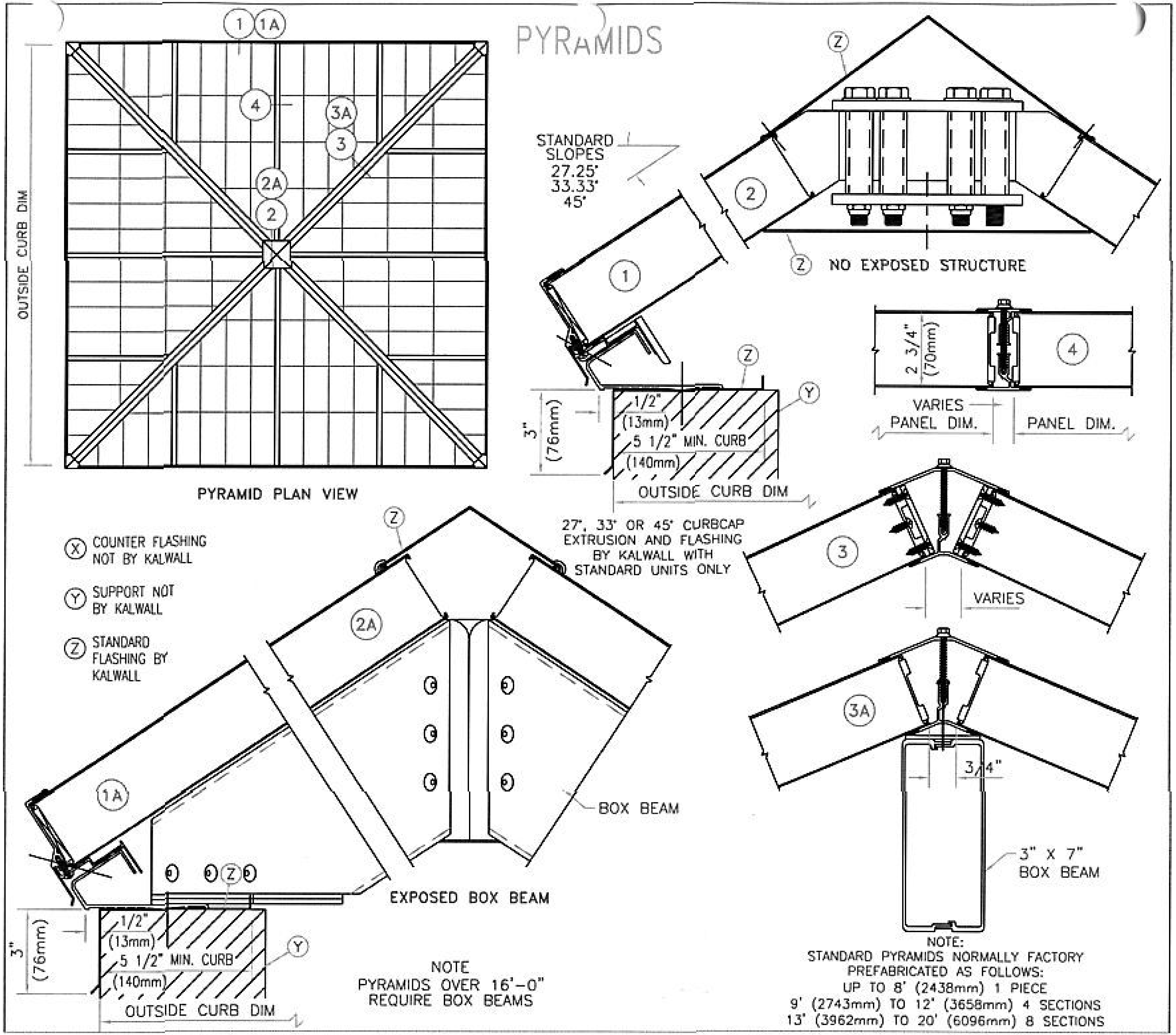


15° CURB CAP
EXTRUSION AND FLASHING
BY KALWALL WITH
STANDARD UNITS ONLY

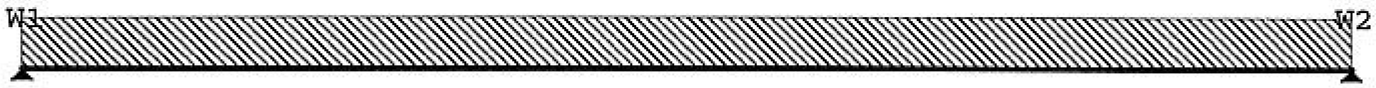
(X) COUNTER FLASHING NOT BY KALWALL

(Y) SUPPORT NOT BY KALWALL

(Z) STANDARD FLASHING BY KALWALL


PYRAMIDS
1
1A
4
3A
3
2A
2
OUTSIDE CURB DIM
PYRAMID PLAN VIEW
STANDARD SLOPES
27.25°
33.33°
45°
Z
2
1
NO EXPOSED STRUCTURE
Z
Y
3"
(76mm)
1/2"
(13mm)
5 1/2" MIN. CURB
(140mm)
OUTSIDE CURB DIM
2 3/4"
(70mm)
4
VARIES
PANEL DIM.
PANEL DIM.
27°, 33° OR 45° CURBCAP EXTRUSION AND FLASHING BY KALWALL WITH STANDARD UNITS ONLY
3
VARIES
X COUNTER FLASHING NOT BY KALWALL
Y SUPPORT NOT BY KALWALL
Z STANDARD FLASHING BY KALWALL
2A
1A
BOX BEAM
EXPOSED BOX BEAM
3A
3/4"
3" X 7" BOX BEAM
NOTE
PYRAMIDS OVER 16'-0" REQUIRE BOX BEAMS
NOTE:
STANDARD PYRAMIDS NORMALLY FACTORY PREFABRICATED AS FOLLOWS:
UP TO 8' (2438mm) 1 PIECE
9' (2743mm) TO 12' (3658mm) 4 SECTIONS
13' (3962mm) TO 20' (6096mm) 8 SECTIONS

RAMSBEAM V2.0 - Load Diagram
Licensed to: Intergrated Project Services
Job: SR DESIGN Steel Code: LRFD
Beam Size = W8X10
Span information (ft):
Length = 10.00, Left Support at 0.00, Right Support at 10.00



Load	Dist	DL	LL+	LL-	Max Tot
W1	0.00	0.153	0.150	0.000	0.303
W2	10.00	0.153	0.150	0.000	0.303

RAMSBEAM V2.0 - Gravity Beam Design
Licensed to: Intergrated Project Services
Job: SR DESIGN Steel Code: LRFD

SPAN INFORMATION:
Beam Size (Optimum) = W8X10 Fy = 50.0 ksi
Total Beam Length (ft) = 10.00
Mp (kip-ft) = 36.96
Top Flange Braced By Decking

LOADS: Self Weight = 0.010 k/ft
Line Loads (k/ft):

Dist1	Dist2	DL1	DL2	Pre DL1	Pre DL2	LL1	LL2
0.00	10.00	0.142	0.142	0.000	0.000	0.150	0.150

SHEAR (Ultimate): Max Vu 1.2DL+1.6LL (kips) = 2.12 0.90Vn = 36.22

MOMENTS:

Span	Cond	LoadCase	Mu kip-ft	@ ft	Lb ft	Cb	Phi	Phi*Mn kip-ft
Center	Max +	1.2DL+1.6LL	5.3	5.0	0.0	1.00	0.90	32.95
Controlling		1.2DL+1.6LL	5.3	5.0	0.0	1.00	0.90	32.95

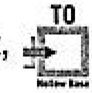
REACTIONS (Unfactored) (kips):

	Left	Right
DL reaction	0.76	0.76
Max + LL reaction	0.75	0.75
Max + total reaction	1.51	1.51

DEFLECTIONS:

Dead load (in)	at	5.00 ft =	-0.038	L/D =	3122
Live load (in)	at	5.00 ft =	-0.038	L/D =	3176 > 360 OK
Total load (in)	at	5.00 ft =	-0.076	L/D =	1574 > 240 OK

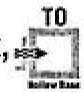
HIT HY20 Allowable Loads for Threaded HIT-A Rods in Hollow Concrete Block, Lightweight Concrete Block, Brick with Holes, Clay Tile



Anchor Type	Anchor Diameter in. (mm)	HIT-A Short 2" (51mm) Embedment		HIT-A Standard 3³/₈" (86mm) Embedment			
		L/W or N/W Hollow Concrete Block		Brick with Holes		Clay Tile	
		Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
HIT-A Rod Anchor	1/4 * (6.4) *	255 (1.1)	340 (1.5)	365 (1.6)	305 (1.4)	130 (0.6)	100 (0.4)
	5/16 (7.9)	370 (1.6)	505 (2.2)	565 (2.5)	530 (2.4)	150 (0.7)	220 (1.0)
	3/8 (9.5)	525 (2.3)	790 (3.5)	775 (3.4)	930 (4.1)	150 (0.7)	220 (2.2)
	1/2 (12.7)	525 (2.3)	1230 (5.5)	775 (3.4)	1375 (6.1)	150 (0.7)	500 (2.2)

* 1/4" anchor diameter installed at 2" embedment in brick with holes and clay tile.

HIT HY20 Allowable Loads for Threaded HIT-I Inserts in Hollow Concrete Block, Lightweight Concrete Block, Brick with Holes, Clay Tile



Anchor Type	Anchor Diameter in. (mm)	HIT Short 2" (51mm) Embedment		HIT Standard 3³/₈" (86mm) Embedment			
		L/W or N/W Hollow Concrete Block		Brick with Holes		Clay Tile	
		Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
HIT-I Insert Anchor	No 14 screw w/ insert * (6.4) *	240 (1.1)	510 (2.3)	300 (1.3)	530 (2.4)	85 (0.4)	150 (0.7)
	5/16 (7.9)	400 (1.8)	780 (3.5)	585 (2.6)	750 (3.3)	175 (0.8)	220 (1.0)
	3/8 (9.5)	400 (1.8)	1425 (6.3)	1160 (5.2)	1380 (6.1)	185 (0.8)	435 (1.9)
	1/2 (12.7)	400 (1.8)	1800 (8.0)	1160 (5.2)	1635 (7.3)	185 (0.8)	500 (2.2)

* 1/4" anchor diameter installed at 2" embedment in brick with holes and clay tile.

Anchor Spacing and Edge Distance Guidelines

Influence of Anchor Spacing and Edge Distance

Brick with Holes and Multi-Wythe Brick Walls

Spacing:
$s_{cr} = s_{min}$ = Two (2) complete bricks in any direction

Edge Distance:
$c_{cr} = c_{min}$ = Two (2) complete bricks, or 16 inches (406 mm) in any direction (whichever is less.)

Clay Tile

Spacing:
$s_{cr} = s_{min}$ = One (1) anchor per tile cell

Edge Distance:
$c_{cr} = c_{min}$ = 12 inches (305 mm) from free edge

Hollow, Normal Weight and Lightweight Concrete Block

Spacing:
$s_{cr} = s_{min}$ = One (1) anchor per block cell

Edge Distance:
$c_{cr} = c_{min}$ = 12' (305 mm) minimum from free edge

Joist Design Summary

	Tributary Area	Span	Design	Number	Cost
Joist Number 1	4.92	29.60	18KCS2	2	$452.94
Joist Number 2	7.08	34.00	24KCS3	2	$722.50
Joist Number 3	6.67	35.33	24KCS3	21	$7,883.01
Joist Number 4	6.67	34.00	22KCS3	14	$5,057.50
Joist Number 5	5.67	34.00	22KCS3	4	$1,445.00
Joist Number 6	5.00	35.33	22KCS3	2	$750.83
Joist Number 7	6.17	34.00	22KCS3	6	$2,167.50
Joist Number 8	7.33	35.33	24KCS3	8	$3,003.33
Joist Number 9	7.00	34.00	24KCS3	6	$2,167.50
Joist Number 10	5.75	34.00	22KCS3	4	$1,445.00
Joist Number 11	4.83	34.33	20KCS3	2	$729.58
Joist Number 12	3.42	34.33	20KCS2	2	$554.48
Joist Number 13	6.50	34.00	22KCS3	3	$1,083.75
Joist Number 14	6.33	35.33	24KCS3	23	$8,634.58
Joist Number 15	4.04	26.00	14KCS2	1	$176.80
Joist Number 16	5.75	26.00	16KCS2	1	$187.85
Joist Number 17	6.67	24.67	16KCS2	8	$1,425.73
Joist Number 18	6.67	26.00	18KCS2	6	$1,193.40
Joist Number 19	6.33	24.67	16KCS2	1	$178.22
Joist Number 20	6.00	26.00	18KCS2	1	$198.90
Joist Number 21	3.67	26.00	14KCS2	1	$176.80
Joist Number 22	1.71	32.00	14KCS1	2	$353.60
Joist Number 23	5.83	32.00	20KCS3	1	$312.80
Joist Number 24	6.67	31.33	20KCS3	3	$918.85
Joist Number 25	5.83	31.33	22KCS2	1	$266.33
Joist Number 26	3.92	16.00	12KCS1	1	$81.60
Joist Number 27	5.83	16.00	12KCS1	2	$163.20
Joist Number 28	5.92	14.67	12KCS1	2	$149.60
Joist Number 29	6.00	16.00	12KCS1	6	$489.60
Joist Number 30	5.75	16.00	12KCS1	1	$81.60
Joist Number 31	5.92	16.00	12KCS1	1	$81.60
Joist Number 32	6.13	14.67	12KCS1	1	$74.80
Joist Number 33	6.50	16.00	12KCS1	1	$81.60
Joist Number 34	6.33	16.00	12KCS1	1	$81.60
Joist Number 35	6.17	16.00	12KCS1	1	$81.60
Joist Number 36	6.33	14.67	12KCS1	2	$149.60
Joist Number 37	6.33	16.00	12KCS1	1	$81.60
Joist Number 38	6.50	14.67	12KCS1	1	$74.80

Joist Design Summary

	Tributary Area	Span	Design	Number	Cost
Joist Number 39	6.67	16.00	12KCS1	1	$81.60
Joist Number 40	6.75	13.15	12KCS1	1	$67.04
Joist Number 41	3.25	24.67	14KCS1	1	$136.28
Joist Number 42	4.50	24.67	14KCS2	1	$167.76
Joist Number 43	5.08	23.33	14KCS2	1	$158.67
Joist Number 44	5.67	24.67	16KCS2	5	$891.08
Joist Number 45	5.67	23.33	14KCS2	2	$317.33
Joist Number 46	5.83	23.33	14KCS2	1	$158.67
Joist Number 47	6.00	24.67	16KCS2	4	$712.87
Joist Number 48	6.33	23.33	14KCS2	1	$158.67
Joist Number 49	6.67	23.33	16KCS2	1	$168.58
Joist Number 50	6.67	23.67	16KCS2	1	$170.99
Joist Number 51	6.42	16.27	12KCS1	1	$82.98
Joist Number 52	3.42	24.67	14KCS1	1	$136.28
Joist Number 53	4.83	24.67	14KCS2	1	$167.73
Joist Number 54	5.25	23.33	14KCS2	1	$158.67
Joist Number 55	5.75	23.33	14KCS2	2	$317.33
Joist Number 56	5.83	24.67	16KCS2	1	$178.22
Joist Number 57	5.50	24.67	14KCS2	1	$167.73
Joist Number 58	6.08	23.33	14KCS2	1	$158.67
Joist Number 59	6.17	24.67	16KCS2	3	$534.65
Joist Number 60	6.42	23.33	14KCS2	1	$158.67
Joist Number 61	7.00	24.00	16KCS2	2	$346.80
Joist Number 62	6.67	18.83	14KCS1	1	$104.05
Joist Number 63	5.67	34.67	24KCS3	4	$1,473.33
Joist Number 64	5.50	33.33	20KCS3	4	$1,303.33
Joist Number 65	6.33	33.33	24KCS3	6	$2,125.00
Joist Number 66	6.33	34.67	24KCS3	4	$1,473.33
Joist Number 67	2.67	35.33	16KCS3	1	$315.35
Joist Number 68	5.17	35.33	24KCS3	3	$1,126.25
Joist Number 69	5.67	35.33	24KCS3	2	$750.83
Joist Number 70	5.83	34.00	24KCS3	1	$361.25
Joist Number 71	6.00	35.33	24KCS3	5	$1,877.08
Joist Number 72	6.75	34.00	24KCS3	1	$361.25
Joist Number 73	4.08	35.33	20KCS3	1	$345.38
Joist Number 74	3.58	35.33	20KCS2	2	$570.63
Joist Number 75	6.33	34.00	24KCS3	16	$5,780.00
Joist Number 76	5.75	34.33	24KCS3	2	$729.58

Joist Design Summary

	Tributary Area	Span	Design	Number	Cost
Joist Number 77	3.08	35.33	20KCS2	3	$855.95
Joist Number 78	5.83	35.33	24KCS3	1	$375.42
Joist Number 79	6.00	34.00	24KCS3	2	$722.50
Joist Number 80	5.67	35.33	24KCS3	4	$1,501.67
Joist Number 81	6.50	34.00	24KCS3	1	$361.25
Joist Number 82	6.67	30.00	20KCS3	2	$586.50
Joist Number 83	6.67	27.58	20KCS2	1	$222.74
Joist Number 84	5.92	34.33	24KCS3	1	$364.79
Joist Number 85	3.75	34.33	20KCS2	1	$277.24
				216	$72,444.34

KCS JOIST LOAD TABLE

(U.S. CUSTOMARY)

JOIST DESIGNATION	DEPTH (inches)	MOMENT CAPACITY* (inch-kips)	SHEAR CAPACITY* (lbs)	APPROX. WEIGHT** (lbs/ft)	GROSS MOMENT OF INERTIA (in^4)	BRIDG. TABLE SECT. NO.
10KCS1	10	172	2000	6.0	29	1
10KCS2	10	225	2500	7.5	37	1
10KCS3	10	296	3000	10.0	47	1
12KCS1	12	209	2400	6.0	43	3
12KCS2	12	274	3000	8.0	55	5
12KCS3	12	362	3500	10.0	71	5
14KCS1	14	247	2900	6.5	59	4
14KCS2	14	324	3400	8.0	77	6
14KCS3	14	428	3900	10.0	99	6
16KCS2	16	349	4000	8.5	99	6
16KCS3	16	470	4800	10.5	128	9
16KCS4	16	720	5300	14.5	192	9
16KCS5	*16*	*934*	*5800*	*18.0*	*245*	*9*
18KCS2	18	395	4700	9.0	127	6
18KCS3	18	532	5200	11.0	164	9
18KCS4	18	817	5700	15.0	247	10
18KCS5	18	1062	6200	18.5	316	10
20KCS2	20	442	5200	9.5	159	6
20KCS3	20	595	6000	11.5	205	9
20KCS4	20	914	7900	16.5	308	10
20KCS5	20	1191	8400	20.0	396	10
22KCS2	*22*	*489*	*5900*	*10.0*	*194*	*6*
22KCS3	22	658	6800	12.5	251	9
22KCS4	22	1012	7900	16.5	377	11
22KCS5	22	1319	8600	20.5	485	11
24KCS2	24	534	6300	10.0	232	6
24KCS3	24	720	7200	12.5	301	9
24KCS4	24	1108	8400	16.5	453	12
24KCS5	24	1448	8900	20.5	584	12
26KCS2	26	580	6600	10.0	274	6
26KCS3	26	783	7800	12.5	355	9
26KCS4	26	1206	8500	16.5	536	12
26KCS5	26	1576	9200	20.5	691	12
28KCS2	28	626	6900	10.5	320	6
28KCS3	28	846	8000	12.5	414	9
28KCS4	28	1303	8500	16.5	626	12
28KCS5	28	1704	9200	20.5	808	12
30KCS3	30	908	8000	13.0	478	9
30KCS4	30	1400	8500	16.5	722	12
30KCS5	30	1833	9200	21.0	934	12

*MAXIMUM UNIFORMLY DISTRIBUTED LOAD CAPACITY IS 550 PLF AND SINGLE CONCENTRATED LOAD CANNOT EXCEED SHEAR CAPACITY.
**DOES NOT INCLUDE ACCESSORIES

Joist Number 1

Tributary Width		4.92 ft		
Span	L	29.60 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	291.07 lbs/ft	$\omega_{tot}=LP$	
			$\omega_{tot}<550$ lbs/ft	OK
Maximum Moment	Mmax	396.84 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000	
Maximum Shear	Vmax	4468.3 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)	
Joist Selection		**18KCS2**		
Depth	d	18 in		
Weight	ω_{jst}	9 lbs/ft		
Moment of Inertia	I	127 in^4		
Moment Capacity (Table)		395 kip-in		
Moment Capacity (LRFD)	Mall	586.6 kip-in	**Mall>Mmax**	OK
Shear Capacity (Table)		*4700 lbs*		
Shear Capacity (LRFD)	Vall	7064.1 lbs	**Vall>Vmax**	OK
Maximum Deflection	Δ	1.4165 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 251	**Δ>L/240**	OK
Number of Joists	n	2		
Cost per Pound	*c*	*$0.85*		
Total Cost	C	$452.94	C=ω_{jst}*L*c*n	

Joist Number 2				
Tributary Width		*7.08 ft*		
Span	L	34.00 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	419.33 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	753.13 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	7383.7 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**24KCS3**		
Depth	d	*24 in*		
Weight	ω_{jst}	12.5 lbs/ft		
Moment of Inertia	I	301 in^4		
Moment Capacity (Table)		720 kip-in		
Moment Capacity (LRFD)	Mall	1069.2 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs		
Shear Capacity (LRFD)	Vall	10821.6 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	1.4961 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 273		**Δ>L/240** OK
Number of Joists	n	2		
Cost per Pound	c	$0.85		
Total Cost	C	$722.50		C=ω_{jst}*L*c*n

Joist Number 3			
Tributary Width		6.67 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	767.02 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	7236.8 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**24KCS3**	
Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		*7200 lbs*	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.6452 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 258	**Δ>L/240** OK
Number of Joists	n	21	
Cost per Pound	c	$0.85	
Total Cost	C	$7,883.01	C=ω_{jst}*L*c*n

Joist Number 4

Tributary Width		6.67 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	710.36 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6964.3 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 22KCS3

Depth	d	22 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	251 in^4	
Moment Capacity (Table)		658 kip-in	
Moment Capacity (LRFD)	Mall	977.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6600 lbs	
Shear Capacity (LRFD)	Vall	9919.8 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.6922 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 241	**Δ>L/240** OK
Number of Joists	n	14	
Cost per Pound	c	$0.85	
Total Cost	C	$5,057.50	C=ω_{jst}*L*c*n

Joist Number 5

Tributary Width		5.67 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	335.47 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	607.71 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	5957.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**22KCS3**	
Depth	d	22 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	251 in^4	
Moment Capacity (Table)		658 kip-in	
Moment Capacity (LRFD)	Mall	977.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6600 lbs	
Shear Capacity (LRFD)	Vall	9919.8 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4477 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 282	**Δ>L/240** OK
Number of Joists	n	4	
Cost per Pound	c	$0.85	
Total Cost	C	$1,445.00	C=ω_{jst}*L*c*n

Joist Number 6

Tributary Width		5.00 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	296.00 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	582.40 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	5494.3 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **22KCS3**

Depth	d	22 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	251 in^4	
Moment Capacity (Table)		*658 kip-in*	
Moment Capacity (LRFD)	Mall	977.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6600 lbs	
Shear Capacity (LRFD)	Vall	9919.8 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	*1.4983 in*	*Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)*
		L/ 283	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$750.83	C=ω_{jst}*L*c*n

Joist Number 7

Tributary Width		6.17 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	365.07 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	659.04 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6461.1 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection: 22KCS3

Depth	d	22 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	251 in^4	
Moment Capacity (Table)		658 kip-in	
Moment Capacity (LRFD)	Mall	977.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6600 lbs	
Shear Capacity (LRFD)	Vall	9919.8 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.5700 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 260	**Δ>L/240** OK
Number of Joists	n	6	
Cost per Pound	c	$0.85	
Total Cost	C	$2,167.50	C=ω_{jst}*L*c*n

Joist Number 8

Tributary Width		7.33 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	434.11 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	841.04 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	7934.3 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 24KCS3

Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		*7200 lbs*	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.8043 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 235	**Δ>L/240** NO GOOD
Number of Joists	n	8	
Cost per Pound	c	*$0.65*	
Total Cost	C	$3,003.33	C=ω_{jst}*L*c*n

Joist Number 9

Tributary Width		7.00 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	414.40 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	744.58 kip-in	Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	7299.8 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		**24KCS3**	
Depth	d	24 in	
Weight	ωjst	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4791 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 276	**Δ>L/240** OK
Number of Joists	n	6	
Cost per Pound	c	$0.85	
Total Cost	C	$2,167.50	C=ωjst*L*c*n

Joist Number 10

Tributary Width		5.75 ft		
Span	L	34.00 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	340.40 lbs/ft	$\omega_{tot}=LP$	
			ω_{tot}<550 lbs/ft	OK
Maximum Moment	Mmax	616.26 kip-in	$M_{max}=(0.125*(\omega_{tot}+1.2*w_{jst})*L^2*12)/1000$	
Maximum Shear	Vmax	6041.8 lbs	$V_{max}=(\omega_{tot}+1.2*\omega_{jst})*(L/2)$	
Joist Selection		**22KCS3**		
Depth	d	22 in		
Weight	ω_{jst}	12.5 lbs/ft		
Moment of Inertia	I	251 in^4		
Moment Capacity (Table)		658 kip-in		
Moment Capacity (LRFD)	Mall	977.1 kip-in	**Mall>Mmax**	OK
Shear Capacity (Table)		6600 lbs		
Shear Capacity (LRFD)	Vall	9919.8 lbs	**Vall>Vmax**	OK
Maximum Deflection	Δ	1.4681 in	$\Delta=(5*(\omega_{tot}+1.2*\omega_{jst})*(L*12)^4)/(384*29000000*I*12)$	
		L/ 278	**Δ>L/240**	OK
Number of Joists	n	4		
Cost per Pound	c	$0.85		
Total Cost	C	$1,445.00	$C=\omega_{jst}*L*c*n$	

Joist Number 11				
Tributary Width		4.83 ft		
Span	L	34.33 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	286.13 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	*Mmax*	*532.45 kip-in*		*Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000*
Maximum Shear	Vmax	5169.5 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		20KCS3		
Depth	d	20 in		
Weight	ω_{jst}	12.5 lbs/ft		
Moment of Inertia	I	205 in^4		
Moment Capacity (Table)		595 kip-in		
Moment Capacity (LRFD)	Mall	883.6 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		6000 lbs		
Shear Capacity (LRFD)	Vall	9018.0 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	1.5836 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 260		**Δ>L/240** OK
Number of Joists	n	2		
Cost per Pound	c	$0.85		
Total Cost	C	$729.58		C=ω_{jst}*L*c*n

Joist Number 12			
Tributary Width		3.42 ft	
Span	L	34.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	202.27 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	*Mmax*	*377.80 kip-in*	*Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000*
Maximum Shear	Vmax	3667.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**20KCS2**	
Depth	d	18 in	
Weight	ω_{jst}	9.5 lbs/ft	
Moment of Inertia	I	159 in^4	
Moment Capacity (Table)		442 kip-in	
Moment Capacity (LRFD)	Mall	656.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		5200 lbs	
Shear Capacity (LRFD)	Vall	7815.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4487 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 284	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$554.48	C=ω_{jst}*L*c*n

Joist Number 13				
Tributary Width		6.50 ft		
Span	L	34.00 ft		
Total Load	P	59.20 psf		
Linear Load	ωtot	384.80 lbs/ft		ωtot=LP
				ωtot<550 lbs/ft OK
Maximum Moment	Mmax	693.25 kip-in		Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	6796.6 lbs		Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		22KCS3		
Depth	d	22 in		
Weight	ωjst	12.5 lbs/ft		
Moment of Inertia	I	251 in^4		
Moment Capacity (Table)		658 kip-in		
Moment Capacity (LRFD)	Mall	977.1 kip-in		Mall>Mmax OK
Shear Capacity (Table)		*6600 lbs*		
Shear Capacity (LRFD)	Vall	9919.8 lbs		Vall>Vmax OK
Maximum Deflection	Δ	1.6515 in		Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 247		Δ>L/240 OK
Number of Joists	n	3		
Cost per Pound	c	$0.85		
Total Cost	C	$1,083.75		C=ωjst*L*c*n

Joist Number 14

Tributary Width		6.33 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	374.93 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft — OK
Maximum Moment	Mmax	730.21 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6888.8 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection: 24KCS3

Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** — OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** — OK
Maximum Deflection	Δ	1.5666 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 271	***Δ>L/240*** — OK
Number of Joists	n	23	
Cost per Pound	c	$0.85	
Total Cost	C	$8,634.58	C=ω_{jst}*L*c*n

Joist Number 15

Tributary Width		4.04 ft	
Span	L	26.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	239.27 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	252.35 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3235.3 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 14KCS2

Depth	d	14 in	
Weight	ω_{jst}	8 lbs/ft	
Moment of Inertia	I	77 in^4	
Moment Capacity (Table)		324 kip-in	
Moment Capacity (LRFD)	Mall	481.1 kip-in	Mall>Mmax OK
Shear Capacity (Table)		3400 lbs	
Shear Capacity (LRFD)	Vall	5110.2 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.1459 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 272	Δ>L/240 OK

Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$176.80	C=ω_{jst}*L*c*n

Joist Number 16

Tributary Width		5.75 ft	
Span	L	26.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	340.40 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	355.51 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4557.8 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**16KCS2**	
Depth	d	16 in	
Weight	ω_{jst}	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.2556 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 248	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$187.85	C=ω_{jst}*L*c*n

Joist Number 17

Tributary Width		6.67 ft	
Span	L	24.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	369.51 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4993.4 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 16KCS2

Depth	d	16 in	
Weight	ω_{jst}	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.1746 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 252	**Δ>L/240** OK
Number of Joists	n	8	
Cost per Pound	c	$0.85	
Total Cost	C	$1,425.73	C=ω_{jst}*L*c*n

Joist Number 18				
Tributary Width		6.67 ft		
Span	L	26.00 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	394.67 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	411.14 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	5271.1 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**18KCS2**		
Depth	d	18 in		
Weight	ω_{jst}	9 lbs/ft		
Moment of Inertia	I	127 in^4		
Moment Capacity (Table)		395 kip-in		
Moment Capacity (LRFD)	Mall	586.6 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		4700 lbs		
Shear Capacity (LRFD)	Vall	7064.1 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	1.1320 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 276		**Δ>L/240** OK
Number of Joists	n	6		
Cost per Pound	c	$0.85		
Total Cost	C	$1,193.40		C=ω_{jst}*L*c*n

Joist Number 19

Tributary Width		6.33 ft	
Span	L	24.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	374.93 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	351.50 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4750.0 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 16KCS2

Depth	d	16 in	
Weight	ω_{jst}	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.1174 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 265	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$178.22	C=ω_{jst}*L*c*n

Joist Number 20			
Tributary Width		6.00 ft	
Span	L	26.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	355.20 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	371.12 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4758.0 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		***18KCS2***	
Depth	d	18 in	
Weight	ω_{jst}	9 lbs/ft	
Moment of Inertia	I	127 in^4	
Moment Capacity (Table)		395 kip-in	
Moment Capacity (LRFD)	Mall	586.6 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4700 lbs	
Shear Capacity (LRFD)	Vall	7064.1 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.0218 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 305	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$198.90	C=ω_{jst}*L*c*n

Joist Number 21			
Tributary Width		3.67 ft	
Span	L	26.00 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	217.07 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	229.84 kip-in	Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	2946.7 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		**14KCS2**	
Depth	d	14 in	
Weight	ωjst	8 lbs/ft	
Moment of Inertia	I	77 in^4	
Moment Capacity (Table)		324 kip-in	
Moment Capacity (LRFD)	Mall	481.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		3400 lbs	
Shear Capacity (LRFD)	Vall	5110.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.0437 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 299	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$176.80	C=ωjst*L*c*n

Joist Number 22

Tributary Width		1.71 ft	
Span	L	32.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	101.13 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	167.32 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	1742.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**14KCS1**	
Depth	d	14 in	
Weight	ω_{jst}	6.5 lbs/ft	
Moment of Inertia	I	59 in^4	
Moment Capacity (Table)		247 kip-in	
Moment Capacity (LRFD)	Mall	366.8 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2900 lbs	
Shear Capacity (LRFD)	Vall	4358.7 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.5021 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 256	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$353.60	C=ω_{jst}*L*c*n

Joist Number 23

Tributary Width		5.83 ft	
Span	L	32.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	345.33 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	551.63 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	5746.1 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **20KCS3**

Depth	d	20 in	
Weight	ω_{jst}	11.5 lbs/ft	
Moment of Inertia	I	205 in^4	
Moment Capacity (Table)		595 kip-in	
Moment Capacity (LRFD)	Mall	883.6 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6000 lbs	
Shear Capacity (LRFD)	Vall	9018.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4252 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 269	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$312.80	C=ω_{jst}*L*c*n

Joist Number 24					
Tributary Width		6.67 ft			
Span	L	31.33 ft			
Total Load	P	59.20 psf			
Linear Load	ω_{tot}	394.69 lbs/ft		ω_{tot}=LP	
				ω_{tot}<550 lbs/ft	OK
Maximum Moment	Mmax	601.56 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000	
Maximum Shear	Vmax	6399.6 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)	
Joist Selection		**20KCS3**			
Depth	d	20 in			
Weight	ω_{jst}	11.5 lbs/ft			
Moment of Inertia	I	205 in^4			
Moment Capacity (Table)		595 kip-in			
Moment Capacity (LRFD)	Mall	883.6 kip-in		**Mall>Mmax**	OK
Shear Capacity (Table)		6000 lbs			
Shear Capacity (LRFD)	Vall	9018.0 lbs		**Vall>Vmax**	OK
Maximum Deflection	Δ	1.4902 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 252		**Δ>L/240**	OK
Number of Joists	n	3			
Cost per Pound	c	$0.85			
Total Cost	C	$918.85		C=ω_{jst}*L*c*n	

Joist Number 25

Tributary Width		5.83 ft	
Span	L	31.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	345.31 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	526.19 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	5597.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 22KCS2

Depth	d	22 in	
Weight	ω_{jst}	10 lbs/ft	
Moment of Inertia	I	194 in^4	
Moment Capacity (Table)		488 kip-in	
Moment Capacity (LRFD)	Mall	724.7 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		5900 lbs	
Shear Capacity (LRFD)	Vall	8867.7 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.3773 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 273	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$266.33	C=ω_{jst}*L*c*n

Joist Number 26				
Tributary Width		3.92 ft		
Span	L	16.00 ft		
Total Load	P	59.20 psf		
Linear Load	ωtot	231.87 lbs/ft		ωtot=LP
				ωtot<550 lbs/ft OK
Maximum Moment	Mmax	91.80 kip-in		Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	1912.5 lbs		Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		**12KCS1**		
Depth	d	12 in		
Weight	ωjst	6 lbs/ft		
Moment of Inertia	I	43 in^4		
Moment Capacity (Table)		209 kip-in		
Moment Capacity (LRFD)	Mall	310.4 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs		
Shear Capacity (LRFD)	Vall	3607.2 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	0.2827 in		Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 679		**Δ>L/240** OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$81.60		C=ωjst*L*c*n

Joist Number 27				
Tributary Width		5.83 ft		
Span	L	16.00 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	345.33 lbs/ft	ω_{tot}=LP	
			ω_{tot}<550 lbs/ft	OK
Maximum Moment	Mmax	135.37 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000	
Maximum Shear	*Vmax*	*2820.3 lbs*	*Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)*	
Joist Selection		**12KCS1**		
Depth	d	12 in		
Weight	ω_{jst}	6 lbs/ft		
Moment of Inertia	I	43 in^4		
Moment Capacity (Table)		209 kip-in		
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax**	OK
Shear Capacity (Table)		*2400 lbs*		
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax**	OK
Maximum Deflection	Δ	0.4169 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 461	**Δ>L/240**	OK
Number of Joists	n	2		
Cost per Pound	c	$0.85		
Total Cost	C	$163.20	C=ω_{jst}*L*c*n	

Joist Number 28

Tributary Width		5.92 ft	
Span	L	14.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	350.27 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	115.34 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	2621.4 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection: 12KCS1

Depth	d	12 in	
Weight	ω_{jst}	6 lbs/ft	
Moment of Inertia	I	43 in^4	
Moment Capacity (Table)		209 kip-in	
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	*Vall*	*3607.2 lbs*	***Vall>Vmax*** OK
Maximum Deflection	Δ	0.2985 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 590	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$149.60	C=ω_{jst}*L*c*n

Joist Number 29

Tributary Width		6.00 ft	
Span	L	16.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	355.20 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	139.16 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	2899.2 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **12KCS1**

Depth	d	12 in	
Weight	ω_{jst}	6 lbs/ft	
Moment of Inertia	I	43 in^4	
Moment Capacity (Table)		209 kip-in	
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.4285 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 448	**Δ>L/240** OK
Number of Joists	n	6	
Cost per Pound	c	$0.85	
Total Cost	C	$489.60	C=ω_{jst}*L*c*n

Joist Number 30				
Tributary Width		5.75 ft		
Span	L	16.00 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	340.40 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	133.48 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	2780.8 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		12KCS1		
Depth	d	12 in		
Weight	ω_{jst}	6 lbs/ft		
Moment of Inertia	I	43 in^4		
Moment Capacity (Table)		209 kip-in		
Moment Capacity (LRFD)	Mall	310.4 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs		
Shear Capacity (LRFD)	Vall	3607.2 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	0.4110 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 467		**Δ>L/240** OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$81.60		C=ω_{jst}*L*c*n

Joist Number 31

Tributary Width		5.92 ft	
Span	L	16.00 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	350.46 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	137.34 kip-in	Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	2861.3 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		**12KCS1**	
Depth	d	12 in	
Weight	ωjst	6 lbs/ft	
Moment of Inertia	I	43 in^4	
Moment Capacity (Table)		*209 kip-in*	
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.4229 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 454	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$81.60	C=ωjst*L*c*n

Joist Number 32

Tributary Width		6.13 ft	
Span	L	14.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	362.60 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	119.32 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	2711.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**12KCS1**	
Depth	d	12 in	
Weight	ω_{jst}	6 lbs/ft	
Moment of Inertia	I	43 in^4	
Moment Capacity (Table)		209 kip-in	
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.3088 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 570	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$74.80	C=ω_{jst}*L*c*n

Joist Number 33				
Tributary Width		6.50 ft		
Span	L	16.00 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	384.80 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	150.53 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3136.0 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		12KCS1		
Depth	d	12 in		
Weight	ω_{jst}	*6 lbs/ft*		
Moment of Inertia	I	43 in^4		
Moment Capacity (Table)		209 kip-in		
Moment Capacity (LRFD)	Mall	310.4 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs		
Shear Capacity (LRFD)	Vall	3607.2 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	0.4635 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 414		**Δ>L/240** OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$81.60		C=ω_{jst}*L*c*n

Joist Number 34			
Tributary Width		6.33 ft	
Span	L	16.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	374.93 lbs/ft	ω_{tot}=LP
			ω_{tot}**<550 lbs/ft** OK
Maximum Moment	Mmax	146.74 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3057.1 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection	12KCS1		
Depth	d	12 in	
Weight	ω_{jst}	6 lbs/ft	
Moment of Inertia	I	43 in^4	
Moment Capacity (Table)		209 kip-in	
Moment Capacity (LRFD)	*Mall*	*310.4 kip-in*	***Mall>Mmax*** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.4519 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 425	Δ>**L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$81.60	C=ω_{jst}*L*c*n

Joist Number 35			
Tributary Width		6.17 ft	
Span	L	16.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	365.07 lbs/ft	ω_{tot}=LP
			ω_{tot}**<550 lbs/ft** OK
Maximum Moment	Mmax	142.95 kip-in	Mmax=(0.125*(ω_{tot}+1.2*W_{jst})*L^2*12)/1000
Maximum Shear	Vmax	2978.1 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		12KCS1	
Depth	d	12 in	
Weight	ω_{jst}	6 lbs/ft	
Moment of Inertia	I	143 in^4	
Moment Capacity (Table)		209 kip-in	
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.1324 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 1451	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$81.60	C=ω_{jst}*L*c*n

Joist Number 36				
Tributary Width		6.33 ft		
Span	L	14.67 ft		
Total Load	P	59.20 psf		
Linear Load	ωtot	374.93 lbs/ft		ωtot=LP
				ωtot<550 lbs/ft OK
Maximum Moment	Mmax	123.30 kip-in		Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	2802.3 lbs		Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		12KCS1		
Depth	d	12 in		
Weight	ωjst	6 lbs/ft		
Moment of Inertia	I	43 in^4		
Moment Capacity (Table)		209 kip-in		
Moment Capacity (LRFD)	Mall	310.4 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs		
Shear Capacity (LRFD)	Vall	3607.2 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	0.3190 in		Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 552		**Δ>L/240** OK
Number of Joists	n	2		
Cost per Pound	c	$0.85		
Total Cost	C	$149.60		C=ωjst*L*c*n

Joist Number 37

Tributary Width		6.33 ft	
Span	L	16.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	374.93 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	146.74 kip-in	Mmax=(0.125*(ω_{tot}+1.2*W_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3057.1 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**12KCS1**	
Depth	d	12 in	
Weight	ω_{jst}	6 lbs/ft	
Moment of Inertia	I	43 in^4	
Moment Capacity (Table)		209 kip-in	
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.4519 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 425	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$81.60	C=ω_{jst}*L*c*n

Joist Number 38

Tributary Width		6.50 ft			
Span	L	14.67 ft			
Total Load	P	59.20 psf			
Linear Load	ω_{tot}	384.80 lbs/ft		$\omega_{tot}=LP$	
				$\omega_{tot}<550$ **lbs/ft**	OK
Maximum Moment	Mmax	126.48 kip-in		$Mmax=(0.125*(\omega_{tot}+1.2*w_{jst})*L^{\wedge}2*12)/1000$	
Maximum Shear	Vmax	2874.7 lbs		$Vmax=(\omega_{tot}+1.2*\omega_{jst})*(L/2)$	
Joist Selection		**12KCS1**			
Depth	d	12 in			
Weight	ω_{jst}	6 lbs/ft			
Moment of Inertia	I	43 in^4			
Moment Capacity (Table)		209 kip-in			
Moment Capacity (LRFD)	Mall	310.4 kip-in		**Mall>Mmax**	OK
Shear Capacity (Table)		2400 lbs			
Shear Capacity (LRFD)	Vall	3607.2 lbs		**Vall>Vmax**	OK
Maximum Deflection	Δ	0.3273 in		$\Delta=(5*(\omega_{tot}+1.2*\omega_{jst})*(L*12)^{\wedge}4)/(384*29000000*I*12)$	
		L/ 538		**Δ>L/240**	OK
Number of Joists	n	1			
Cost per Pound	c	$0.85			
Total Cost	C	$74.80		$C=\omega_{jst}*L*c*n$	

Joist Number 39

Tributary Width		6.67 ft	
Span	L	16.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	154.32 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3214.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 12KCS1

Depth	d	12 in		
Weight	ω_{jst}	6 lbs/ft		
Moment of Inertia	I	43 in^4		
Moment Capacity (Table)		209 kip-in		
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax**	OK
Shear Capacity (Table)		2400 lbs		
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax**	OK
Maximum Deflection	Δ	0.4752 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 404	**Δ>L/240**	OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$81.60	C=ω_{jst}*L*c*n	

Joist Number 42				
Tributary Width		4.50 ft		
Span	L	24.67 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	266.40 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	251.96 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3404.5 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		14KCS2		
Depth	d	14 in		
Weight	ω_{jst}	8 lbs/ft		
Moment of Inertia	I	77 in^4		
Moment Capacity (Table)		324 kip-in		
Moment Capacity (LRFD)	Mall	481.1 kip-in		Mall>Mmax OK
Shear Capacity (Table)		3400 lbs		
Shear Capacity (LRFD)	Vall	5110.2 lbs		Vall>Vmax OK
Maximum Deflection	Δ	1.0301 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 287		Δ>L/240 OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$167.76		C=ω_{jst}*L*c*n

Joist Number 43

Tributary Width		5.08 ft	
Span	L	23.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	300.93 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	253.60 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3622.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 14KCS2

Depth	d	14 in	
Weight	ω_{jst}	8 lbs/ft	
Moment of Inertia	I	77 in^4	
Moment Capacity (Table)		324 kip-in	
Moment Capacity (LRFD)	Mall	481.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		3400 lbs	
Shear Capacity (LRFD)	Vall	5110.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.9275 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 302	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$158.67	C=ω_{jst}*L*c*n

Joist Number 44				
Tributary Width		5.67 ft		
Span	L	24.67 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	335.47 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	315.48 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4263.2 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**16KCS2**		
Depth	d	16 in		
Weight	ω_{jst}	8.5 lbs/ft		
Moment of Inertia	I	99 in^4		
Moment Capacity (Table)		349 kip-in		
Moment Capacity (LRFD)	Mall	518.3 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		*4000 lbs*		
Shear Capacity (LRFD)	Vall	6012.0 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	1.0029 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 295		**Δ>L/240** OK
Number of Joists	n	5		
Cost per Pound	c	$0.85		
Total Cost	C	$891.08		C=ω_{jst}*L*c*n

Joist Number 45

Tributary Width		5.67 ft	
Span	L	23.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	335.47 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	281.80 kip-in	Mmax=(0.125*(ω_{tot}+1.2*W_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4025.8 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **14KCS2**

Depth	d	14 in		
Weight	ω_{jst}	8 lbs/ft		
Moment of Inertia	I	77 in^4		
Moment Capacity (Table)		324 kip-in		
Moment Capacity (LRFD)	Mall	481.1 kip-in	**Mall>Mmax**	OK
Shear Capacity (Table)		3400 lbs		
Shear Capacity (LRFD)	Vall	5110.2 lbs	**Vall>Vmax**	OK
Maximum Deflection	Δ	1.0306 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 272	**Δ>L/240**	OK
Number of Joists	n	2		
Cost per Pound	c	$0.85		
Total Cost	C	$317.33	C=ω_{jst}*L*c*n	

Joist Number 46

Tributary Width		5.83 ft	
Span	L	23.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	345.33 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	289.86 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4140.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **14KCS2**

Depth	d	14 in		
Weight	ω_{jst}	8 lbs/ft		
Moment of Inertia	I	77 in^4		
Moment Capacity (Table)		324 kip-in		
Moment Capacity (LRFD)	Mall	481.1 kip-in	Mall>Mmax	OK
Shear Capacity (Table)		3400 lbs		
Shear Capacity (LRFD)	Vall	5110.2 lbs	Vall>Vmax	OK
Maximum Deflection	Δ	1.0601 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 264	Δ>L/240	OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$158.67	C=ω_{jst}*L*c*n	

Joist Number 47

Tributary Width		6.00 ft	
Span	L	24.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	355.20 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	333.49 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4506.6 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**16KCS2**	
Depth	d	16 in	
Weight	ω_{jst}	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.0601 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 279	**Δ>L/240** OK
Number of Joists	n	4	
Cost per Pound	c	$0.85	
Total Cost	C	$712.87	C=ω_{jst}*L*c*n

Joist Number 48					
Tributary Width		6.33 ft			
Span	L	23.33 ft			
Total Load	P	59.20 psf			
Linear Load	ω_{tot}	374.93 lbs/ft		ω_{tot}=LP	
				ω_{tot}<550 lbs/ft	OK
Maximum Moment	Mmax	314.04 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000	
Maximum Shear	Vmax	4486.2 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)	
Joist Selection		**14KCS2**			
Depth	d	14 in			
Weight	ω_{jst}	8 lbs/ft			
Moment of Inertia	I	77 in^4			
Moment Capacity (Table)		324 kip-in			
Moment Capacity (LRFD)	Mall	481.1 kip-in		**Mall>Mmax**	OK
Shear Capacity (Table)		3400 lbs			
Shear Capacity (LRFD)	Vall	5110.2 lbs		**Vall>Vmax**	OK
Maximum Deflection	Δ	1.1485 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 244		**Δ>L/240**	OK
Number of Joists	n	1			
Cost per Pound	c	$0.85			
Total Cost	C	$158.67		C=ω_{jst}*L*c*n	

Joist Number 49			
Tributary Width		6.67 ft	
Span	L	23.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	330.64 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4723.4 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		16KCS2	
Depth	d	16 in	
Weight	ω_{jst}	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.9405 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 298	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$168.58	C=ω_{jst}*L*c*n

Joist Number 50

Tributary Width		6.67 ft	
Span	L	23.67 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	394.67 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	340.16 kip-in	Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	4790.9 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)

Joist Selection **16KCS2**

Depth	d	16 in	
Weight	ωjst	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.9954 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 285	***Δ>L/240*** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$170.99	C=ωjst*L*c*n

Joist Number 51

Tributary Width		6.42 ft	
Span	L	16.27 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	379.87 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	153.71 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3148.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **12KCS1**

Depth	d	12 in	
Weight	ω_{jst}	6 lbs/ft	
Moment of Inertia	I	43 in^4	
Moment Capacity (Table)		209 kip-in	
Moment Capacity (LRFD)	Mall	310.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2400 lbs	
Shear Capacity (LRFD)	Vall	3607.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.4895 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 399	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$82.98	C=ω_{jst}*L*c*n

Joist Number 52

Tributary Width		3.42 ft	
Span	L	24.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	202.27 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	191.72 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	2590.8 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection: 14KCS1

Depth	d	14 in	
Weight	ω_{jst}	6.5 lbs/ft	
Moment of Inertia	I	59 in^4	
Moment Capacity (Table)		247 kip-in	
Moment Capacity (LRFD)	Mall	366.8 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2900 lbs	
Shear Capacity (LRFD)	Vall	4358.7 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.0227 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 289	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$136.28	C=ω_{jst}*L*c*n

Joist Number 53

Tributary Width		4.83 ft	
Span	L	24.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	286.13 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	269.91 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3647.4 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 14KCS2

Depth	d	14 in	
Weight	ω_{jst}	8 lbs/ft	
Moment of Inertia	I	77 in^4	
Moment Capacity (Table)		324 kip-in	
Moment Capacity (LRFD)	Mall	481.1 kip-in	Mall>Mmax OK
Shear Capacity (Table)		3400 lbs	
Shear Capacity (LRFD)	Vall	5110.2 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.1032 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 268	Δ>L/240 OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$167.73	C=ω_{jst}*L*c*n

Joist Number 54			
Tributary Width		5.25 ft	
Span	L	23.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	310.80 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	261.66 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3738.0 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		14KCS2	
Depth	d	14 in	
Weight	ω_{jst}	8 lbs/ft	
Moment of Inertia	I	77 in^4	
Moment Capacity (Table)		324 kip-in	
Moment Capacity (LRFD)	Mall	481.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		3400 lbs	
Shear Capacity (LRFD)	Vall	5110.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.9570 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 293	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$158.67	C=ω_{jst}*L*c*n

Joist Number 55

Tributary Width		5.75 ft	
Span	L	23.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	340.40 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	285.83 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4083.3 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 14KCS2

Depth	d	14 in	
Weight	ω_{jst}	8 lbs/ft	
Moment of Inertia	I	77 in^4	
Moment Capacity (Table)		324 kip-in	
Moment Capacity (LRFD)	Mall	481.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		3400 lbs	
Shear Capacity (LRFD)	Vall	5110.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.0454 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 268	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$317.33	C=ω_{jst}*L*c*n

Joist Number 56

Tributary Width		5.83 ft	
Span	L	24.67 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	345.33 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	324.48 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4384.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 16KCS2

Depth	d	16 in	
Weight	ω_{jst}	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.0315 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 287	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$178.22	C=ω_{jst}*L*c*n

Joist Number 57				
Tributary Width		5.50 ft		
Span	L	24.67 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	325.60 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	305.93 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4134.1 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		14KCS2		
Depth	d	14 in		
Weight	ω_{jst}	8 lbs/ft		
Moment of Inertia	I	77 in^4		
Moment Capacity (Table)		324 kip-in		
Moment Capacity (LRFD)	Mall	481.1 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		3400 lbs		
Shear Capacity (LRFD)	Vall	5110.2 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	1.2504 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 237		**Δ>L/240** NO GOOD
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$167.73		C=ω_{jst}*L*c*n

Joist Number 58

Tributary Width		6.08 ft	
Span	L	23.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	360.13 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	301.95 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4313.6 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **14KCS2**

Depth	d	14 in	
Weight	ω_{jst}	8 lbs/ft	
Moment of Inertia	I	77 in^4	
Moment Capacity (Table)		324 kip-in	
Moment Capacity (LRFD)	Mall	481.1 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		3400 lbs	
Shear Capacity (LRFD)	Vall	5110.2 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.1043 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 254	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$158.67	C=ω_{jst}*L*c*n

Joist Number 59

Tributary Width		6.17 ft	
Span	L	24.67 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	365.07 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	342.49 kip-in	Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	4628.3 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)

Joist Selection **16KCS2**

Depth	d	16 in	
Weight	ωjst	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.0888 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 272	**Δ>L/240** OK
Number of Joists	n	3	
Cost per Pound	c	$0.85	
Total Cost	C	$534.65	C=ωjst*L*c*n

Joist Number 60				
Tributary Width		6.42 ft		
Span	L	23.33 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	379.87 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	318.06 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4543.8 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**14KCS2**		
Depth	d	14 in		
Weight	ω_{jst}	8 lbs/ft		
Moment of Inertia	I	77 in^4		
Moment Capacity (Table)		324 kip-in		
Moment Capacity (LRFD)	Mall	481.1 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		3400 lbs		
Shear Capacity (LRFD)	Vall	5110.2 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	1.1632 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 241		**Δ>L/240** OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$158.67		C=ω_{jst}*L*c*n

Joist Number 61			
Tributary Width		7.00 ft	
Span	L	24.00 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	414.40 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	366.85 kip-in	Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	5095.2 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		**16KCS2**	
Depth	d	16 in	
Weight	ωjst	8.5 lbs/ft	
Moment of Inertia	I	99 in^4	
Moment Capacity (Table)		349 kip-in	
Moment Capacity (LRFD)	Mall	518.3 kip-in	Mall>Mmax OK
Shear Capacity (Table)		4000 lbs	
Shear Capacity (LRFD)	Vall	6012.0 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.1040 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 261	Δ>L/240 OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$346.80	C=ωjst*L*c*n

Joist Number 62			
Tributary Width		6.67 ft	
Span	L	18.83 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	214.13 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3789.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**14KCS1**	
Depth	d	14 in	
Weight	ω_{jst}	6.5 lbs/ft	
Moment of Inertia	I	59 in^4	
Moment Capacity (Table)		247 kip-in	
Moment Capacity (LRFD)	Mall	366.8 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2900 lbs	
Shear Capacity (LRFD)	Vall	4358.7 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.6658 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 339	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$104.05	C=ω_{jst}*L*c*n

Joist Number 63

Tributary Width		5.67 ft		
Span	L	34.67 ft		
Total Load	P	*59.20 psf*		
Linear Load	ω_{tot}	335.47 lbs/ft	ω_{tot}=LP	
			ω_{tot}<550 lbs/ft	OK
Maximum Moment	Mmax	631.77 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000	
Maximum Shear	Vmax	6074.8 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)	

Joist Selection	24KCS3

Depth	d	24 in		
Weight	ω_{jst}	12.5 lbs/ft		
Moment of Inertia	I	301 in^4		
Moment Capacity (Table)		720 kip-in		
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax**	OK
Shear Capacity (Table)		*7200 lbs*		
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax**	OK
Maximum Deflection	Δ	1.3047 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 319	**Δ>L/240**	OK
Number of Joists	n	4		
Cost per Pound	c	$0.85		
Total Cost	C	$1,473.33	C=ω_{jst}*L*c*n	

Joist Number 64

Tributary Width		5.50 ft	
Span	L	33.33 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	325.60 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	565.67 kip-in	Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	5656.7 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)

Joist Selection **20KCS3**

Depth	d	20 in	
Weight	ωjst	11.5 lbs/ft	
Moment of Inertia	I	205 in^4	
Moment Capacity (Table)		595 kip-in	
Moment Capacity (LRFD)	Mall	883.6 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6000 lbs	
Shear Capacity (LRFD)	Vall	9018.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.5858 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 252	**Δ>L/240** OK
Number of Joists	n	4	
Cost per Pound	c	$0.85	
Total Cost	C	$1,303.33	C=ωjst*L*c*n

Joist Number 65

Tributary Width		6.33 ft	
Span	L	33.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	374.93 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	649.89 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6498.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 24KCS3

Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	*301 in^4*	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.2409 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 322	**Δ>L/240** OK

Number of Joists	n	6	
Cost per Pound	c	$0.85	
Total Cost	C	$2,125.00	C=ω_{jst}*L*c*n

Joist Number 66

Tributary Width		6.33 ft	
Span	L	34.67 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	374.93 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	702.92 kip-in	Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	6758.8 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)

Joist Selection 24KCS3

Depth	d	24 in	
Weight	ωjst	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4516 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 287	**Δ>L/240** OK
Number of Joists	n	4	
Cost per Pound	c	$0.85	
Total Cost	C	$1,473.33	C=ωjst*L*c*n

Joist Number 67			
Tributary Width		2.67 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	157.87 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	319.23 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3011.6 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**16KCS3**	
Depth	d	16 in	
Weight	ω_{jst}	10.5 lbs/ft	
Moment of Inertia	I	128 in^4	
Moment Capacity (Table)		470 kip-in	
Moment Capacity (LRFD)	Mall	698.0 kip-in	Mall>Mmax OK
Shear Capacity (Table)		4800 lbs	
Shear Capacity (LRFD)	Vall	7214.4 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.6105 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 263	Δ>L/240 OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$315.35	C=ω_{jst}*L*c*n

Joist Number 68

Tributary Width		5.17 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	305.87 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	600.88 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	5668.6 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**24KCS3**	
Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.2891 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 329	**Δ>L/240** OK
Number of Joists	n	3	
Cost per Pound	c	$0.85	
Total Cost	C	$1,126.25	C=ω_{jst}*L*c*n

Joist Number 69

Tributary Width		5.67 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	335.47 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	656.31 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6191.6 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 24KCS3

Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4080 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 301	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$750.83	C=ω_{jst}*L*c*n

Joist Number 70				
Tributary Width		5.83 ft		
Span	L	34.00 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	345.33 lbs/ft		ω_{tot}=LP
				ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	624.82 kip-in		Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6125.7 lbs		Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		24KCS3		
Depth	d	24 in		
Weight	ω_{jst}	12.5 lbs/ft		
Moment of Inertia	I	301 in^4		
Moment Capacity (Table)		720 kip-in		
Moment Capacity (LRFD)	Mall	1069.2 kip-in		Mall>Mmax OK
Shear Capacity (Table)		7200 lbs		
Shear Capacity (LRFD)	Vall	10821.6 lbs		Vall>Vmax OK
Maximum Deflection	Δ	1.2412 in		Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 329		Δ>L/240 OK
Number of Joists	n	1		
Cost per Pound	c	$0.85		
Total Cost	C	$361.25		C=ω_{jst}*L*c*n

Joist Number 71

Tributary Width		6.00 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	355.20 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	693.26 kip-in	Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	6540.2 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		**24KCS3**	
Depth	d	24 in	
Weight	ωjst	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4873 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 285	**Δ>L/240** OK
Number of Joists	n	5	
Cost per Pound	c	$0.85	
Total Cost	C	$1,877.08	C=ωjst*L*c*n

Joist Number 72

Tributary Width		6.75 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	399.60 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	718.92 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	7048.2 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**24KCS3**	
Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.4281 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 286	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$361.25	C=ω_{jst}*L*c*n

Joist Number 73

Tributary Width		4.08 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	241.73 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	478.53 kip-in	Mmax=(0.125*(ω_{tot}+1.2*W_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4514.4 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **20KCS3**

Depth	d	20 in	
Weight	ω_{jst}	11.5 lbs/ft	
Moment of Inertia	I	205 in^4	
Moment Capacity (Table)		595 kip-in	
Moment Capacity (LRFD)	Mall	883.6 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6000 lbs	
Shear Capacity (LRFD)	Vall	9018.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.5074 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 281	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$345.38	C=ω_{jst}*L*c*n

Joist Number 74				
Tributary Width		3.58 ft		
Span	L	35.33 ft		
Total Load	P	59.20 psf		
Linear Load	ω_{tot}	212.13 lbs/ft	ω_{tot}=LP	
			ω_{tot}<550 lbs/ft	OK
Maximum Moment	Mmax	418.60 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000	
Maximum Shear	Vmax	3949.1 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)	
Joist Selection		20KCS2		
Depth	d	20 in		
Weight	ω_{jst}	9.5 lbs/ft		
Moment of Inertia	I	159 in^4		
Moment Capacity (Table)		442 kip-in		
Moment Capacity (LRFD)	Mall	656.4 kip-in	Mall>Mmax	OK
Shear Capacity (Table)		5200 lbs		
Shear Capacity (LRFD)	Vall	7815.6 lbs	Vall>Vmax	OK
Maximum Deflection	Δ	1.7001 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 249	Δ>L/240	OK
Number of Joists	n	2		
Cost per Pound	c	$0.85		
Total Cost	C	$570.63	C=ω_{jst}*L*c*n	

Joist Number 75

Tributary Width		6.33 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	374.93 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	676.14 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6628.9 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 24KCS3

Depth	d	24 in		
Weight	ω_{jst}	12.5 lbs/ft		
Moment of Inertia	I	301 in^4		
Moment Capacity (Table)		720 kip-in		
Moment Capacity (LRFD)	Mall	1069.2 kip-in	Mall>Mmax	OK
Shear Capacity (Table)		7200 lbs		
Shear Capacity (LRFD)	Vall	10821.6 lbs	Vall>Vmax	OK
Maximum Deflection	Δ	1.3431 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)	
		L/ 304	Δ>L/240	OK
Number of Joists	n	16		
Cost per Pound	c	$0.85		
Total Cost	C	$5,780.00	C=ω_{jst}*L*c*n	

Joist Number 76			
Tributary Width		5.75 ft	
Span	L	34.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	340.40 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	628.41 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6101.0 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		24KCS3	
Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.2729 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 324	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$729.58	C=ω_{jst}*L*c*n

Joist Number 77

Tributary Width		3.08 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	182.53 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	363.17 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	3426.2 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection **20KCS2**

Depth	d	20 in	
Weight	ω_{jst}	9.5 lbs/ft	
Moment of Inertia	I	159 in^4	
Moment Capacity (Table)		442 kip-in	
Moment Capacity (LRFD)	Mall	656.4 kip-in	Mall>Mmax OK
Shear Capacity (Table)		5200 lbs	
Shear Capacity (LRFD)	Vall	7815.6 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.4750 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 287	Δ>L/240 OK
Number of Joists	n	3	
Cost per Pound	c	$0.85	
Total Cost	C	$855.95	C=ω_{jst}*L*c*n

Joist Number 78			
Tributary Width		5.83 ft	
Span	L	35.33 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	345.33 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	674.78 kip-in	Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	6365.9 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		24KCS3	
Depth	d	24 in	
Weight	ωjst	12.5 lbs/ft	
Moment of Inertia	I	251 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	Mall>Mmax OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.7360 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 244	Δ>L/240 OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$375.42	C=ωjst*L*c*n

Joist Number 79

Tributary Width		6.00 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	355.20 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	641.93 kip-in	Mmax=(0.125*(ωtot+1.2*wjst)*L^2*12)/1000
Maximum Shear	Vmax	6293.4 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)

Joist Selection 24KCS3

Depth	d	24 in	
Weight	ωjst	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	Mall>Mmax OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.2752 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 320	Δ>L/240 OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$722.50	C=ωjst*L*c*n

Joist Number 80				
Tributary Width		5.67 ft		
Span	L	35.33 ft		
Total Load	P	59.20 psf		
Linear Load	ωtot	335.47 lbs/ft		ωtot=LP
				ωtot<550 lbs/ft OK
Maximum Moment	Mmax	656.31 kip-in		Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	6191.6 lbs		Vmax=(ωtot+1.2*ωjst)*(L/2)
Joist Selection		**24KCS3**		
Depth	d	24 in		
Weight	ωjst	12.5 lbs/ft		
Moment of Inertia	I	301 in^4		
Moment Capacity (Table)		720 kip-in		
Moment Capacity (LRFD)	Mall	1069.2 kip-in		**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs		
Shear Capacity (LRFD)	Vall	10821.6 lbs		**Vall>Vmax** OK
Maximum Deflection	Δ	1.4080 in		Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 301		**Δ>L/240** OK
Number of Joists	n	4		
Cost per Pound	c	$0.85		
Total Cost	C	$1,501.67		C=ωjst*L*c*n

Joist Number 81

Tributary Width		6.50 ft	
Span	L	34.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	384.80 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	693.25 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6796.6 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**24KCS3**	
Depth	d	24 in	
Weight	ω_{jst}	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.3771 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 296	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$361.25	C=ω_{jst}*L*c*n

Joist Number 82

Tributary Width		6.67 ft	
Span	L	30.00 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	551.43 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	6127.0 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection 20KCS3

Depth	d	20 in	
Weight	ω_{jst}	11.5 lbs/ft	
Moment of Inertia	I	205 in^4	
Moment Capacity (Table)		595 kip-in	
Moment Capacity (LRFD)	Mall	883.6 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		6000 lbs	
Shear Capacity (LRFD)	Vall	9018.0 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.2522 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 287	**Δ>L/240** OK
Number of Joists	n	2	
Cost per Pound	c	$0.85	
Total Cost	C	$586.50	C=ω_{jst}*L*c*n

Joist Number 83

Tributary Width		6.67 ft	
Span	L	27.58 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	394.67 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	463.43 kip-in	Mmax=(0.125*(ω_{tot}+1.2*W_{jst})*L^2*12)/1000
Maximum Shear	Vmax	5600.3 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		**20KCS2**	
Depth	d	20 in	
Weight	ω_{jst}	9.5 lbs/ft	
Moment of Inertia	I	159 in^4	
Moment Capacity (Table)		442 kip-in	
Moment Capacity (LRFD)	Mall	656.4 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		5200 lbs	
Shear Capacity (LRFD)	Vall	7815.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.1470 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 289	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$222.74	C=ω_{jst}*L*c*n

Joist Number 84

Tributary Width		5.92 ft	
Span	L	34.33 ft	
Total Load	P	59.20 psf	
Linear Load	ωtot	350.27 lbs/ft	ωtot=LP
			ωtot<550 lbs/ft OK
Maximum Moment	Mmax	645.85 kip-in	Mmax=(0.125*(ωtot+1.2*Wjst)*L^2*12)/1000
Maximum Shear	Vmax	6270.4 lbs	Vmax=(ωtot+1.2*ωjst)*(L/2)

Joist Selection **24KCS3**

Depth	d	24 in	
Weight	ωjst	12.5 lbs/ft	
Moment of Inertia	I	301 in^4	
Moment Capacity (Table)		720 kip-in	
Moment Capacity (LRFD)	Mall	1069.2 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		7200 lbs	
Shear Capacity (LRFD)	Vall	10821.6 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	1.3083 in	Δ=(5*(ωtot+1.2*ωjst)*(L*12)^4)/(384*29000000*I*12)
		L/ 315	**Δ>L/240** OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$364.79	C=ωjst*L*c*n

Joist Number 85			
Tributary Width		3.75 ft	
Span	L	34.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	222.00 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	412.69 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4006.7 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)
Joist Selection		20KCS2	
Depth	d	20 in	
Weight	ω_{jst}	9.5 lbs/ft	
Moment of Inertia	I	159 in^4	
Moment Capacity (Table)		442 kip-in	
Moment Capacity (LRFD)	Mall	656.4 kip-in	Mall>Mmax OK
Shear Capacity (Table)		5200 lbs	
Shear Capacity (LRFD)	Vall	7815.6 lbs	Vall>Vmax OK
Maximum Deflection	Δ	1.5825 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 260	Δ>L/240 OK
Number of Joists	n	1	
Cost per Pound	c	$0.85	
Total Cost	C	$277.24	C=ω_{jst}*L*c*n

Joist Number 86

Tributary Width		7.08 ft	
Span	L	19.33 ft	
Total Load	P	59.20 psf	
Linear Load	ω_{tot}	419.33 lbs/ft	ω_{tot}=LP
			ω_{tot}<550 lbs/ft OK
Maximum Moment	Mmax	239.48 kip-in	Mmax=(0.125*(ω_{tot}+1.2*w_{jst})*L^2*12)/1000
Maximum Shear	Vmax	4129.0 lbs	Vmax=(ω_{tot}+1.2*ω_{jst})*(L/2)

Joist Selection	14KCS1

Depth	d	14 in	
Weight	ω_{jst}	6.5 lbs/ft	
Moment of Inertia	I	59 in^4	
Moment Capacity (Table)		247 kip-in	
Moment Capacity (LRFD)	Mall	366.8 kip-in	**Mall>Mmax** OK
Shear Capacity (Table)		2900 lbs	
Shear Capacity (LRFD)	Vall	4358.7 lbs	**Vall>Vmax** OK
Maximum Deflection	Δ	0.7847 in	Δ=(5*(ω_{tot}+1.2*ω_{jst})*(L*12)^4)/(384*29000000*I*12)
		L/ 296	**Δ>L/240** OK
Number of Joists	n	54	
Cost per Pound	c	$0.85	
Total Cost	C	$5,768.10	C=ω_{jst}*L*c*n

STANDARD LOAD TABLE/LONGSPAN STEEL JOISTS, LH-SERIES

Based on a Maximum Allowable Tensile Stress of 30 ksi

Joist Designation	Approx. Wt. in Lbs. per Linear Ft. (Joists Only)	Depth in Inches	SAFE LOAD* in Lbs. Between 28–32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
24LH03	11	24	11500	342	339	336	323	307	293	279	267	255	244	234	224	215	207	199	191
				235	226	218	204	188	175	162	152	141	132	124	116	109	102	96	90
24LH04	12	24	14100	419	398	379	360	343	327	312	298	285	273	262	251	241	231	222	214
				288	265	246	227	210	195	182	169	158	148	138	130	122	114	107	101
24LH05	13	24	15100	449	446	440	419	399	380	363	347	331	317	304	291	280	269	258	248
				308	297	285	264	244	226	210	196	182	171	160	150	141	132	124	117
24LH06	16	24	20300	604	579	555	530	504	480	457	437	417	399	381	364	348	334	320	307
				411	382	356	331	306	284	263	245	228	211	197	184	172	161	152	142
24LH07	17	24	22300	665	638	613	588	565	541	516	491	468	446	426	407	389	373	357	343
				452	421	393	367	343	320	297	276	257	239	223	208	195	182	171	161
24LH08	18	24	23800	707	677	649	622	597	572	545	520	497	475	455	435	417	400	384	369
				480	447	416	388	362	338	314	292	272	254	238	222	208	196	184	173
24LH09	21	24	28000	832	808	785	764	731	696	663	632	602	574	548	524	501	480	460	441
				562	530	501	460	424	393	363	337	313	292	272	254	238	223	209	196
24LH10	23	24	29600	882	856	832	809	788	768	737	702	668	637	608	582	556	533	511	490
				596	559	528	500	474	439	406	378	351	326	304	285	266	249	234	220
24LH11	25	24	31200	927	900	875	851	829	807	787	768	734	701	671	642	616	590	567	544
				624	588	555	525	498	472	449	418	388	361	337	315	294	276	259	243

Joist Designation	Approx. Wt.	Depth	Safe Load 33–40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
28LH05	13	28	14000	337	323	310	297	286	275	265	255	245	237	228	220	213	206	199	193
				219	205	192	180	169	159	150	142	133	126	119	113	107	102	97	92
28LH06	16	28	18600	448	429	412	395	379	364	350	337	324	313	301	291	281	271	262	253
				289	270	253	238	223	209	197	186	175	166	156	148	140	133	126	120
28LH07	17	28	21000	505	484	464	445	427	410	394	379	365	352	339	327	316	305	295	285
				326	305	285	267	251	236	222	209	197	186	176	166	158	150	142	135
28LH08	18	28	22500	540	517	496	475	456	438	420	403	387	371	357	344	331	319	308	297
				348	325	305	285	268	252	236	222	209	196	185	175	165	156	148	140
28LH09	21	28	27700	667	639	612	586	563	540	519	499	481	463	446	430	415	401	387	374
				428	400	375	351	329	309	291	274	258	243	228	216	204	193	183	173
28LH10	23	28	30300	729	704	679	651	625	600	576	554	533	513	495	477	460	444	429	415
				466	439	414	388	364	342	322	303	285	269	255	241	228	215	204	193
28LH11	25	28	32500	780	762	736	711	682	655	629	605	582	561	540	521	502	485	468	453
				498	475	448	423	397	373	351	331	312	294	278	263	249	236	223	212
28LH12	27	28	35700	857	837	818	800	782	766	737	709	682	656	632	609	587	566	546	527
				545	520	496	476	454	435	408	383	361	340	321	303	285	270	256	243
28LH13	30	28	37200	895	874	854	835	816	799	782	766	751	722	694	668	643	620	598	577
				569	543	518	495	472	452	433	415	396	373	352	332	314	297	281	266

Joist Designation	Approx. Wt.	Depth	38-46	47-48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
32LH06	14	32	16700	16700	338	326	315	304	294	284	275	266	257	249	242	234	227	220	214	208
					211	199	189	179	169	161	153	145	138	131	125	119	114	108	104	99
32LH07	16	32	18800	18800	379	366	353	341	329	318	308	298	288	279	271	262	254	247	240	233
					235	223	211	200	189	179	170	162	154	146	140	133	127	121	116	111
32LH08	17	32	20400	20400	411	397	383	369	357	345	333	322	312	302	293	284	275	267	259	252
					255	242	229	216	205	194	184	175	167	159	151	144	137	131	125	120
32LH09	21	32	25600	25600	516	498	480	463	447	432	418	404	391	379	367	356	345	335	325	315
					319	302	285	270	256	243	230	219	208	198	189	180	172	164	157	149
32LH10	21	32	28300	28300	571	550	531	512	495	478	462	445	430	416	402	389	376	364	353	342
					352	332	315	297	282	267	254	240	228	217	206	196	186	178	169	162
32LH11	24	32	31000	31000	625	602	580	560	541	522	505	488	473	458	443	429	416	403	390	378
					385	363	343	325	308	292	277	263	251	239	227	216	206	196	187	179
32LH12	27	32	36400	36400	734	712	688	664	641	619	598	578	559	541	524	508	492	477	463	449
					450	428	406	384	364	345	327	311	295	281	267	255	243	232	221	211
32LH13	30	32	40600	40600	817	801	785	771	742	715	690	666	643	621	600	581	562	544	527	511
					500	480	461	444	420	397	376	354	336	319	304	288	275	262	249	238
32LH14	33	32	41800	41800	843	826	810	795	780	766	738	713	688	665	643	622	602	583	564	547
					515	495	476	458	440	417	395	374	355	337	321	304	290	276	264	251
32LH15	35	32	43200	43200	870	853	837	821	805	791	776	763	750	725	701	678	656	635	616	597
					532	511	492	473	454	438	422	407	393	374	355	338	322	306	292	279

Joist Designation	Approx. Wt.	Depth	42-46	47-56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
36LH07	16	36	16800	16800	292	283	274	266	258	251	244	237	230	224	218	212	207	201	196	191
					177	168	160	153	146	140	134	128	122	117	112	107	103	99	95	91
36LH08	18	36	18500	18500	321	311	302	293	284	276	268	260	253	246	239	233	227	221	215	209
					194	185	176	168	160	153	146	140	134	128	123	118	113	109	104	100
36LH09	21	36	23700	23700	411	398	386	374	363	352	342	333	323	314	306	297	289	282	275	267
					247	235	224	214	204	195	186	179	171	163	157	150	144	138	133	127
36LH10	21	36	26100	26100	454	440	426	413	401	389	378	367	357	347	338	328	320	311	303	295
					273	260	248	236	225	215	206	197	188	180	173	165	159	152	146	140
36LH11	23	36	28500	28500	495	480	465	451	438	425	412	401	389	378	368	358	348	339	330	322
					297	283	269	257	246	234	224	214	205	196	188	180	173	166	159	153
36LH12	25	36	34100	34100	593	575	557	540	523	508	493	478	464	450	437	424	412	400	389	378
					354	338	322	307	292	279	267	255	243	232	222	213	204	195	187	179
36LH13	30	36	40100	40100	697	675	654	634	615	596	579	562	546	531	516	502	488	475	463	451
					415	395	376	359	342	327	312	298	285	273	262	251	240	231	222	213
36LH14	36	36	44200	44200	768	755	729	706	683	661	641	621	602	584	567	551	535	520	505	492
					456	434	412	392	373	356	339	323	309	295	283	270	259	247	237	228
36LH15	36	36	46600	46600	809	795	781	769	744	721	698	677	656	637	618	600	583	567	551	536
					480	464	448	434	413	394	375	358	342	327	312	299	286	274	263	252

RAM Steel V6.2 Gravity Beam Design Takeoff
Integrated Project Services

DataBase: temp 02/26/01 12:10:03
Building Code: BOCA Steel Code: ASD 9th Ed.

Floor Type: Overhang
Story Level 1

Steel Grade: 50

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W8X10	25	309.00	3112.32
W10X12	5	96.33	1160.42
W12X14	5	86.67	1226.82
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	35		5499.56

Total Number of Studs = 0

RAM Steel V6.2 Gravity Beam Design Summary
Integrated Project Services

DataBase: temp 02/26/01 12:23:41
Building Code: BOCA Steel Code: ASD 9th Ed.

Floor Type: Overhang

Beam #	Length ft	+M kip-ft	-M kip-ft	Seff in3	Fy ksi	Beam Size	Studs
1	14.50	14.3	0.0	7.8	50.0	W8X10	
6	19.17	10.3	0.0	7.8	50.0	W8X10	
66	19.17	18.3	0.0	14.9	50.0	W12X14	
9	19.17	9.7	0.0	7.8	50.0	W8X10	
2	14.50	27.6	0.0	14.9	50.0	W12X14	
7	19.00	10.1	0.0	7.8	50.0	W8X10	
65	19.00	18.0	0.0	10.9	50.0	W10X12	
10	19.00	9.5	0.0	7.8	50.0	W8X10	
3	14.50	27.8	0.0	14.9	50.0	W12X14	
8	19.50	10.7	0.0	10.9	50.0	W10X12	
64	19.50	19.0	0.0	14.9	50.0	W12X14	
11	19.50	10.0	0.0	7.8	50.0	W8X10	
4	7.50	0.0	0.0	7.8	50.0	W8X10	
5	7.00	0.0	0.0	7.8	50.0	W8X10	
18	15.00	5.9	0.0	7.8	50.0	W8X10	
24	15.00	5.9	0.0	7.8	50.0	W8X10	
12	7.00	0.0	0.0	7.8	50.0	W8X10	
19	15.00	5.9	0.0	7.8	50.0	W8X10	
25	15.00	5.9	0.0	7.8	50.0	W8X10	
13	7.00	0.0	0.0	7.8	50.0	W8X10	
20	15.00	5.9	0.0	7.8	50.0	W8X10	
26	15.00	5.9	0.0	7.8	50.0	W8X10	
14	7.00	0.0	0.0	7.8	50.0	W8X10	
21	15.00	5.9	0.0	7.8	50.0	W8X10	
27	15.00	5.9	0.0	7.8	50.0	W8X10	
15	7.00	0.0	0.0	7.8	50.0	W8X10	
22	15.00	5.9	0.0	7.8	50.0	W8X10	
28	15.00	5.9	0.0	7.8	50.0	W8X10	
16	7.00	0.0	0.0	7.8	50.0	W8X10	
23	15.00	5.9	0.0	7.8	50.0	W8X10	
29	15.00	5.9	0.0	7.8	50.0	W8X10	
17	7.00	0.0	0.0	7.8	50.0	W8X10	
50	16.00	6.7	0.0	7.8	50.0	W8X10	
48	16.00	6.7	0.0	7.8	50.0	W8X10	
49	7.00	0.0	0.0	7.8	50.0	W8X10	

* after Size denotes beam failed stress/capacity criteria.
# after Size denotes beam failed deflection criteria.
u after Size denotes this size has been assigned by the User.

DataBase: temp 02/26/01 12:23:41
Building Code: BOCA Steel Code: ASD 9th Ed.

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	5	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 6 - B

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	15	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 6 - C

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	6	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 7 - B

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	14	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 7 - C

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	7	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 8 - B

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	13	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 8 - C

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	8	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 9 - B

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	12	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 9 - C

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	9	9.00	2.3	0.5	0.9	0.0	2.8	3.7

Column Line 10 - B

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	11	9.00	2.4	0.5	0.9	0.0	2.9	3.8

Column Line 10 - C

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	10	9.00	2.4	0.5	0.9	0.0	2.9	3.8

Column Line 11 - B

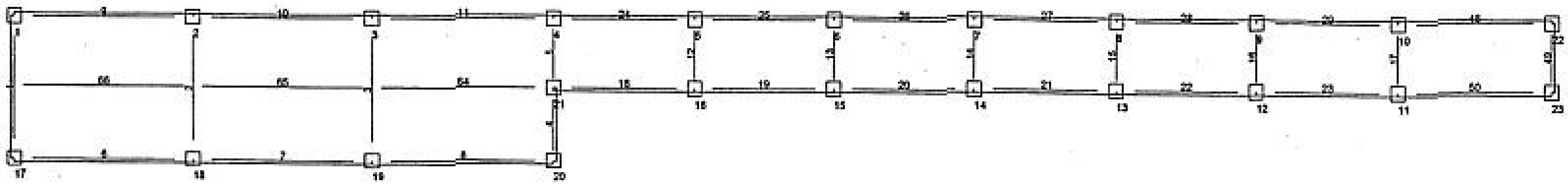
DataBase: temp
02/26/01 12:23:41
Building Code: BOCA
Steel Code: ASD 9th Ed.

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	23	9.00	1.3	0.5	0.5	0.0	1.8	2.3

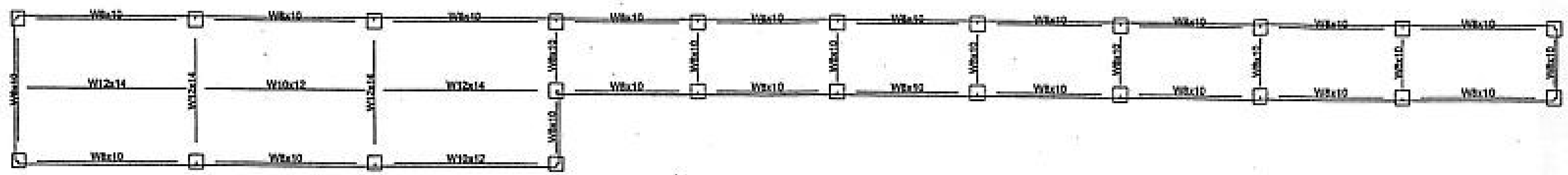
Column Line 11 - C

Level	Col#	Height	Dead	Self	+Live	-Live	MinTot	MaxTot
Overhang	22	9.00	1.3	0.5	0.5	0.0	1.8	2.3

RAM Steel V6.2 Floor Map
DataBase: temp 02/26/01 12:23:41
Building Code: BOCA
Floor Type: Overhang



RAM Steel V6.2 Floor Map
DataBase: temp   02/26/01 12:23:41
Building Code: BOCA
Floor Type: Overhang



HVAC Appendix

List of Sections:

A. Design Conditions

B. Design Criteria

C. System Alternatives

D. Envelope Construction

E. Load Calculations (Summary)

F. System Design

G. Economics

H. Energy Optimization Strategies

I. Case Studies (Summary)

K. Energy Analysis

L. Equipment Cut Sheets

M. System Details

N. Case Studies (Articles)

O. Load Calculations (Trace 700 Tables)

P. References

HVAC Appendix

A. Design Conditions

Lat.	Long.	Elev. (ft)	Std P (psia)	Winter		Summer		
				Heating DB (F)	Extreme Wind Speed (mph)	Cooling DB (F)	Cooling WB (F)	Range of DB (F)
				99%	2.5%	1%	1%	
35.52	108.78	6470	11.57	5	20	87	56	30.6

Table 1: Exterior Design Conditions (Source: 1997 ASHRAE Fundamentals Handbook)

Table 1 displays the outdoor design conditions for Gallup, New Mexico, which, at a distance of approximately 25 miles away, is the closest major city to St. Michaels.

Interior Design Temperatures:
Summer: dry bulb temperature = 78 F, wet bulb temperature = 65 F
Winter: 68 F

These interior design conditions were selected based on ASHRAE design standards to ensure comfortable conditions while reducing energy use.

B. Design Criteria

As was mentioned earlier in this report, the design goals for the HVAC system are as follows:

- Energy efficiency
- Low costs (operational/maintenance as well as initial)
- Comfortable temperature levels
- Adequate moisture content of air
- Air cleanliness
- Adequate supply of fresh outdoor air
- Proper air distribution and circulation
- No noise intrusion during system operation

C. System Alternatives

- Thermal Ice Storage
- Radiant Panel Heating and Cooling
- Fan Coil Units
- Rooftop PTACs & Baseboard Heating
- Water Source Heat Pumps with Ground Loop Heat Exchanger

Thermal ice storage system

System Description: Ice storage systems function by using manufactured ice to satisfy the building cooling loads. Chillers are used to make the ice at night when electricity rates are lowest, and the ice is stored in modular ice tanks. The chillers are turned off during the day when utility rates are high, and the ice is used to cool a water-glycol solution which is pumped to the cooling coils of the air-handling equipment.

System Advantages: This system can result in decreased energy expense. The system is also relatively easy to install and requires limited maintenance, since the tanks are factory assembled and contain no moving parts.

System Disadvantages: The primary justification for this type of system is the on-peak versus off-peak utility rate of electricity. As long as the charge for electricity is much less at night during the off-peak time period, than there will be significant savings in operational costs. However, according to the Navajo Tribal Utility Authority (NTUA), there is no difference in the utility rates during the night versus during the day. The NTUA does not manufacture the electricity distributed across the Navajo Nation. Instead, the electricity is purchased from an outside source and then distributed. Also, while the tanks themselves require limited maintenance, the chillers required to generate the ice would be huge (over 100 tons of cooling required), and would be maintenance intensive. Finally, while the system can be very effective during the cooling season, it is useless during the winter months when heating is required.

Radiant heating and cooling panels

System Description: A radiant panel system is composed of panels mounted on the floor, walls, or ceiling. These panels are temperature controlled using some medium to deliver heat such as water, air, or electric current.

System Advantages: This type of system can potentially produce optimum comfort because the heat is radiated directly to the occupied space. The amount of supply air is usually dependant on the requirement for ventilation and humidification only, meaning the air handling units are small compared to other system types, and there is less concern of draftiness. No mechanical equipment is placed in the occupied space, which is an enormous advantage for projects where space is at a premium. The system produces very little if any noise intrusion to the conditioned space.

System Disadvantages: The time required for the space to reach a comfortable temperature level (lag-time) can be very lengthy for this type of system. Also, the response time can be slow as well. Meaning, if conditions fluctuate throughout the day, this system may not be capable of producing a thermally comfortable environment. Improper installation can result in non-uniform surface temperatures and insufficient heating capacity.

Fan coil units

System Description: Fan coil units provide cooling and heating by forcing air across a coil and channeling it to the space to be conditioned. The air then returns back to the unit, mixes with outdoor air, passes across the coil, and again is redistributed to the space. The units rely on chilled or hot water, and therefore separate components (i.e. condensers for chilled water; boiler(s) for hot water) are also required with the system.

System Advantages: This type of system requires little space for ductwork. Individual temperature control can be achieved using fan coil units. Also, the units can provide heat using low-temperature water, which is an attractive feature if the use of solar energy or heat recovery refrigeration equipment is incorporated in the design.

System Disadvantages: Fan coil units are much more maintenance intensive than other types of HVAC systems. Also, the maintenance usually must occur in the conditioned space, resulting in a disturbance to those occupying the room. The filters used in fan coil units are generally small and inefficient. Finally, fan coil units are not very energy efficient and they can result in high levels of noise intrusion.

Packaged rooftop air-conditioning units with baseboard heating

System Description: A packaged rooftop unit has the compressor and condenser already built into it, thus eliminating the need for a separate cooling tower or chiller. The unit brings in outdoor air and mixes it with return air, filters it, and then passes the air across a heating or cooling coil before it is channeled to the conditioned spaces. A boiler would be needed to supply hot water to the hot water coils in the rooftop units, and also supply hot water to the baseboard heaters. The baseboard heaters would be used to account for the heat loss at the perimeter of all the spaces through the exterior walls.

System Advantages: Packaged rooftop units are generally very easy to install, as the units are factory assembled and arrive on site ready to operate. The existing facility at St. Michaels makes use of an air-handling unit for the solar building, so there is a history of use of this type of system at the site. In addition, electrical baseboard heating is common throughout the existing campus, which again demonstrates that the system can be implemented at this facility.

System Disadvantages: This type of system is fairly maintenance intensive and expensive to install and operate.

Ground source heat pump

System Description: A ground source heat pump utilizes the earth as both a source of heat during the cooling stage, and as a place to reject heat during the cooling season. The components of the system are a series of underground, plastic piping channeled in either a vertical or horizontal configuration. The buried pipes contain a water/glycol solution or brine. This solution is used to transfer heat either to or from the refrigerant in the water-to-refrigerant heat exchanger. The refrigerant is then piped to the various terminal heat pump units within the spaces to be conditioned.

System Advantages: This system can be very energy efficient, resulting in lower operational costs. There are limited maintenance requirements since a boiler and a chiller are not required. There is very little ductwork incorporated in the system. The terminal units can be fit for outside air intakes, which would negate the requirement of a separate ventilation system.

System Disadvantages: This system, due to the amount of digging and/or trenching involved, can be very expensive to install. Also, if not properly designed, the system will not perform as expected, which is true for any HVAC system.

	Thermal Ice Storage	Radiant Panels	Fan Coil Units	PTACs & Baseboard	GSHP
Energy Efficiency	•	•			•
Initial Cost			•		
Maintenance		•			•
Ind. Temp. Control	•	•	•	•	•
Humidity Control	•		•	•	•
Ventilation	•		•	•	•
Air Filtering	•		•	•	•
Air Distribution	•		•	•	•
Noise Intrusion	•	•		•	•
Heating Capability		•	•	•	•
Cooling Capability	•	•	•	•	•

Table 2: HVAC System-Design Criteria Matrix

Table 2 displays each system alternative and whether or not certain parameters are satisfied by the system. The matrix clearly indicates that the ground source heat pump system is capable of satisfying all of the important design considerations. The only major drawback of the system is the increased cost of installation.

D. Envelope Construction

The building envelope plays a pivotal role in terms of the heat gain/loss in a building. Of particular concern is the amount of glazing or window area on the exterior facades of the building. Typically, the largest cooling loads are generated via solar heat gain through the windows. Therefore, from an energy saving standpoint, the following window area distribution was established:

north facade: max 50% window area w/respect to wall
south facade: max 20% window area w/respect to wall
east facace: max 40% window area w/respect to wall
west facade: max 30% window area w/respect to wall

The north façade typically receives the least exposure to direct sunlight, which is a maximum of 50% window area with respect to the wall area was allowed on the north side. Conversely, the south side of a building typically receives the greatest amount of exposure to the sun. Thus, a maximum of 20% window area with respect to the wall area on the south side was allotted. The glazing for the east, west, and south facades will be a clear, triple-coated, ¼ inch glass, and for the north façade the glazing will be clear, double-coated ¼ inch glass. Since it was determined that tinted windows was not a desirable option at the school, a coated glazing was selected in order to provide high resistance to heat transfer as well as help reduce the solar heat gain during the summer.

In terms of the rest of the building envelope construction, their heat transfer coefficients are as follows:

Wall construction: $U = 0.022982$ BTU/hr-ft^2-F
Roof construction: $U = 0.04684$ BTU/hr-ft^2-F
Floor construction: $U = 0.143336$ BTU/hr-ft2-F

Refer to Section 'M' of this appendix for the envelope construction diagrams.

E. Load Calculations

The values presented in this section for heating and cooling loads were obtained using Trace Load 700, a building load-calculating software produced by Trane. In the program, the site of the building is identified, which allows the software to utilize the proper weather characteristics of the desired location; the HVAC system is specified and modeled; and each room in the building is modeled according to room dimensions, envelope construction, number of occupants, level of activity, schedule of occupancy, and lighting and other miscellaneous equipment types and usage. Refer to the Trace Load 700 tables in Section 'O' of this appendix for the results generated by the software. Below is a summary of the peak building loads and along with the peak loads of some spaces.

	Cooling (tons)	Heating (MBh)
Peak Building Loads:	**110**	**586.2**
Average Classroom (11 total):	4.8	30.2
Cafeteria:	11.0	58.2
Kitchen:	2.0	11.3
Average Physical Therapy (2 total):	3.0	19.4
Administration Area:	5.0	25.0
Conference Room (3 total):	2.0	8.8
Macramé Room:	2.0	13.6
Nurse's Office:	2.0	17.5
Pottery Room:	3.3	19.2
Average Office (4 total):	1.5	4.3

As is usually the case in warm climates such as Arizona and New Mexico, the building peak cooling load of 110 tons (1,320 MBh) is more than twice the peak heating load (586.2 MBh). Therefore, the HVAC system must be sized to accommodate the cooling load, with the assumption being that, as long as the cooling load is larger than the heating load, a system sized for the peak cooling load will easily be able to offset the heating load.

F. System Design

It has been determined that the system best suited for the new multi-purpose facility at St. Michaels is a hybrid HVAC system consisting of a ground source heat pump system and packaged rooftop makeup air units. Refer to Section 'M' in this appendix for a ground source heat pump system schematic.

Ground Source Heat Exchanger

The type of soil at the site can be a critical factor in determining whether or not a ground loop system is a viable option. Some of the more important characteristics in terms of this type of system are soil temperature, moisture content, thermal conductivity/resistance, and soil and rock hardness. The following soil characteristics exist at the site of St. Michaels:

Soil classification:	moist, clayey sand
Thermal conductivity:	0.8 - 1.2 BTU/hr-ft-°F
Thermal resistance:	1.25 - 0.833 hr-ft-°F/BTU
Subsurface soil temperature:	59 °F

The required size of the underground heat exchanger can be approximated based on the above soil characteristics, the outside design conditions, and the peak cooling and heating loads of the building. GeoDesigner 3.0, produced by ClimateMaster, is a software program used to design ground source heat pump systems. Though it is intended for use in residential applications, it was determined that this software would be satisfactory for this project. The following results were obtained using GeoDesigner 3.0:

Required bore length = 36,000 ft
Selected bore depth = 300 ft/bore
Selected pipe diameter = 1 in

Typical requirements for bore lengths for ground source heat pump systems ranges from 125 ft/ton for cold climates to 300 ft/ton for warm climates. Based on the peak cooling load of 110 tons, and the calculated required bore length of 36,000 ft, that results in a bore length of 327.3 ft/ton. Therefore, since it exceeds the typical value for a warm climate, it can be said that our initial calculation for required bore length is a conservative estimate. The error probably results due to the fact that the intended use of the GeoDesigner software is for residential applications, and not large commercial buildings such as the one we are designing. The load patterns seen in a commercial building are more complex and varied compared to the loads in a residential building. Once the bore length and depth have been determined, the number of bores required along with the surface area required for the ground loop field can be determined.

120 boreholes, spaced on 20 foot centers
12 column by 10 row layout
Total surface area of ground loop field = 48,000 ft^2 = 1.1 acre

48,000 ft^2 might seem like a great deal of surface area, and actually it would be difficult to provide that much area if our site was located in an urban setting. However, such is not the case, and providing the needed area for the ground loop field should not be a problem. The proposed location of the ground loop is directly beneath the new proposed parking lot to the south of the proposed building. There are no hazards or concerns associated with locating the pipes beneath the parking lot. If needed, the loop field could be buried directly beneath the building without cause for concern.

The fluid flowing through the ground loop piping will be a brine solution consisting of a glycol ethylene mixture. To promote high efficiency, the liquid flow rate for the system will be between 2.0 and 3.0 gpm/ton. Therefore, total flow rate thru the ground loop piping is equal to:

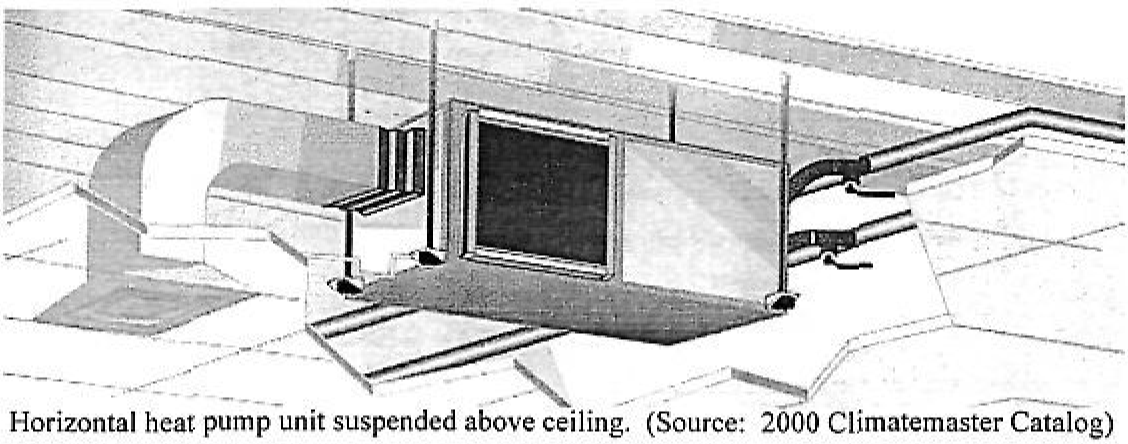
$$(3.0 \text{ gpm/ton}) \times (110 \text{ tons}) = 330 \text{ gpm}$$

And if we consider that there will be 120 bores, flow rate through each pipe is equal to:

$$(330 \text{ gpm})/(120 \text{ bores}) = 2.75 \text{ gpm in each bore}$$

At a flow rate of 330 gpm, and an equivalent head loss of over 300 feet, sizing of the pumps becomes a critical factor in the performance of the buried heat exchanger. In an effort to reduce the risk of drastically over-sizing the pump, the concept of using two pumps sized at less than peak capacity has been implemented. Therefore, while one 75 HP pump would be needed during peak conditions, we shall specify two 40 HP pumps instead. In doing so, one of the pumps will ordinarily function on a stand-by basis during moderate periods. One of the 40 HP pumps will function on a continuous basis to circulate the brine solution during periods of off-peak building loads. As the load approaches peak cooling requirements, the standby 40 HP pump will activate and help to generate the flow rate necessary for peak system operation. Using one 40 HP pump at close to maximum capacity during the majority of the time is more energy efficient than using a 75 HP pump at half of its capacity for the majority of the time. For additional information on our pump selection, refer to Section 'L' (selection made using Bell & Gossett pump selection web page).

Interior Units

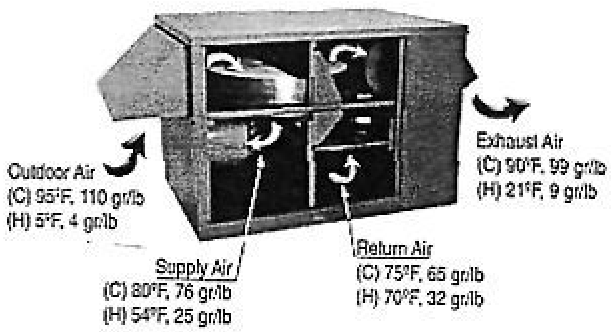


Horizontal heat pump unit suspended above ceiling. (Source: 2000 Climatemaster Catalog)

The interior units for the HVAC system will consist of high efficiency, extended range water source heat pumps. There are a variety of different types of heat pump orientations available, including horizontal units, vertical units, vertical stacked units (more compact than typical vertical units), console units, large commercial units, and rooftop units. Our initial choice for the type of orientation to use consisted of the classroom console unit. To satisfy the average classroom load of approximately 5 tons, three 1.5-ton console units could be placed in each classroom. One might observe that this would only produce 4.5 tons of cooling and argue that this is not sufficient to ensure comfort. While this may seem like a valid argument, the designer for these types of system is encouraged to undersize the equipment in order to increase operating efficiency. An oversized unit will never function at full efficiency, and energy along with money paid upfront will be wasted. However, due to the size of the classrooms (typical area equals 2600 ft^2) and also the various divisions within each classroom, there were concerns regarding proper air distribution. Therefore it was decided that the water source heat pumps will be horizontal units located above the ceiling. The air will be supplied to the spaces to be conditioned via supply air ductwork and diffusers, and the air will be returned to the unit via return ductwork and return grilles. The major concern with this type of design is to ensure that there is enough space above the ceiling to locate the heat pump unit and corresponding ductwork, the makeup air unit and corresponding ductwork, as well as piping, conduit, structural members, etc. This should not be a problem for this particular project, however, due to the minimum 36" between the suspended ceiling and the roof construction throughout the building. Refer to Section 'L' for cut sheets and performance data of heat pumps we are specifying.

Estimated number of horizontal units: 40
Capacity range: 1-½ to 5 tons.
Fluid flow rates: 4.5 – 15.0 GPM
Entering Fluid Temperatures: Summer- 60°F - 75°F; Winter- 45°F – 60°F
Air flow rates: 600 – 2000 CFM
Expected Efficiencies: Cooling-EER = 14 - 16; Heating-COP = 3.8 - 4.5

Makeup Air Units



Rooftop makeup air unit. Source: Semco Product Catalog

Ventilation to all of the conditioned spaces is to be accomplished via rooftop makeup air units. Though it is possible to handle outside air requirements using the heat pump units, the decision to use rooftop units for ventilation came about for two primary reasons. First, by breaking out the outside air load from the total building load, the ground heat exchanger loop could be sized smaller, thus reducing initial expense. Also, the number of heat pump units utilized in the building would increase significantly in order to be able to handle the additional load brought on by conditioning the outside air, thus resulting in greater demand for maintenance. A better solution to the ventilation requirements is to locate several rooftop units for multiple zones throughout the building. The responsibility of the makeup air units will be to condition the incoming outside air and supply the required 20 CFM/person of outdoor air. Outside air volumes supplied to the spaces will be controlled via CO_2 monitors, which will allow the unit to supply the required amount of air based on room occupancy. The outside air will be supplied at a temperature of 80 ± 5°F all year round. The total number of makeup air units required for our building has been estimated to be around 10 units, each sized between 3000 and 5000 CFM. Refer to pages Section 'L' for cut sheets and performance data of rooftop units we are specifying.

G. Economics

Installation costs:

Drilling and Piping for Ground Loop:	$250,000
Heat pumps, Rooftop Units, Ductwork, Pumps, etc.:	$687,750
Total:	**$937,750** **= $13.4/ft²**

H. Energy Optimization Strategies

Energy Recovery Wheel in Makeup Air Units

The roof-mounted makeup air units will supply 100% outdoor air to the spaces within the building. Since the units are required to supply the ventilation air at 80 F, 50% RH on a year-round basis regardless of outside conditions, obviously these units can use up an exorbitant amount of energy, particularly during the heating season when the outside temperature may be less than 10 F and the air temperature has to be increased 70 F to meet satisfactory levels. However, there is a way to reduce the wasted energy associated with 100% outdoor air systems. The solution is to incorporate an energy recovery wheel within each of the units. The device works very much as the name suggests, recovering both sensible (temperature) and latent (moisture) energy from the return air and distributing it to the supply air.

Digital Control System

The purpose of the digital control system is to modulate various aspect of the HVAC system to ensure that there exists a comfortable environment within the building. Components of the system shall include thermostats (for monitoring temperature), humidistats (for monitoring humidity level), and CO_2 sensors (for monitoring occupancy levels via the amount of carbon dioxide in the air). These monitoring devices are connected to a central control panel which is also connected to a computer terminal. Based on the feedback from the various sensors, the system can send a signal to various components of the HVAC system (such as the heat pumps, air handing units, and end-suction pumps circulating the brine solution) to modulate airflow or fluid flow, as the case may be. The presence of this type of control system will allow for energy savings by eliminating the chance of excess cooling or heating, and also by shutting down the system when the school is not in operation or during times when certain spaces within the building are not being occupied.

Heat Pumps used to Preheat Domestic Water

One of the advantages in using a heat pump system to condition a building is the opportunity to use the units to heat the domestic hot water. Though a special heat pump unit is required to handle this task, it functions in the same manner as the water source heat pumps that are discussed earlier in this appendix. Heat energy is extracted from the ground loop, and is then transferred to the domestic water. Due to the rather large peak demand for this building (approximately 1400 gal/hr), the heat pumps would not be used to heat the domestic water entirely. Instead, the heat pumps would be used to pre-heat the water and thus reduce the amount of energy used by the boiler to heat the water to the required temperature.

I. Case Studies

Throughout this term, much research was conducted on ground source heat pump systems. Of particular interest to our design team was gathering information which supported the notion of using the ground source heat pump technology for a commercial school building. In years past, the technology was used primarily in residential applications. However, in recent years as the understanding of how the system works has increased, along with its impressive performance, ground source heat pumps have gained recognition as a design solution for commercial buildings as well.

In this section, two case studies are presented for two schools. Daniel Boone High School, located in Washington County, Tennessee, is a 160,000 square foot facility with a cooling load of 300 tons. The HVAC system installed at the school consists of a closed loop, vertical ground source heat pump system. The loop field is comprised of 320 bores, each at a depth of 150 feet and containing ¾" polyethylene piping. The study discusses the many merits of the ground source heat pump system and clearly demonstrates the type of potential for success for this type of system. It also presents the idea of using variable flow pumping of the brine solution through the ground loop as well as to the units to reduce energy use. Refer to Section 'N' in this appendix for the case study article.

Paint Lick Elementary School is located in Garrard County, Kentucky. The building covers just under 40,000 square feet and has a cooling load of 120 tons. The loop field consists of a total of 144 bores ranging in depth from 163 feet deep to 188 feet deep. This installation served as a "pilot project," meaning that it was one of the first installations of this type for a commercial building in the state of Kentucky. The project was such a success that the school received an Engineering Excellence Award. Refer to Section 'N' in this appendix for the case study article.

These case studies are just two examples out of many that indicate how well ground source heat pumps can work in a commercial setting. It is our belief that the same type of results in terms of energy savings and system performance can be attained at St. Michaels.

K. Annual Energy Consumption

The operational cost of occupying and maintaining a school may sometimes be even more important than the up front cost of constructing the building. Many factors can influence the operational cost of a school, such as: the climate, the construction of the building envelope, and selection of an HVAC system to name a few. FBM has decided to model the school in Energy 10, a software that uses climatory data and complex equations to calculate annual energy usage.

The first simulation compares our building with a traditional HVAC system to our building with a ground source heat pump. The traditional system picked is a PTAC heat pump with electric reheat backup. This system operates at a COP of 3.3 and an EER of 10. FBM is predicting a COP of 4.5 and an EER of 15. As you can see, the difference in the overall energy usage is mainly due to the energy saved in cooling (see variant 1), 5.2 kBtu/sqft.

The second simulation is an attempt to tighten the building envelope and building systems. Better insulation was used. Energy efficient lights were installed. Air infiltration through the building envelope was reduced. Also the HVAC system was tuned. An economizer cycle was utilized in conjunction with heating and cooling setbacks. Duct leakage was kept to a minimum. Variant 5 shows a reduction of 6.3 kBtu/sqft for lights and 3.5 kBtu/sqft for cooling.

The third simulation incorporates shading as well as different glazing into St. Michael's. The U value for the window was reduced by half but, the energy for cooling only declined .3 kBtu /sq ft.

FBM has been concerned about the amount of daylight in each classroom. The fourth simulation increases the size of window from the standard 4'x6' to a 6'x6', a window area increase of 33%.

St. Michaels
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments:

May 11, 2001
Weather file: albqrque.et1
Saved as X:\ENERGY10, Var. 1

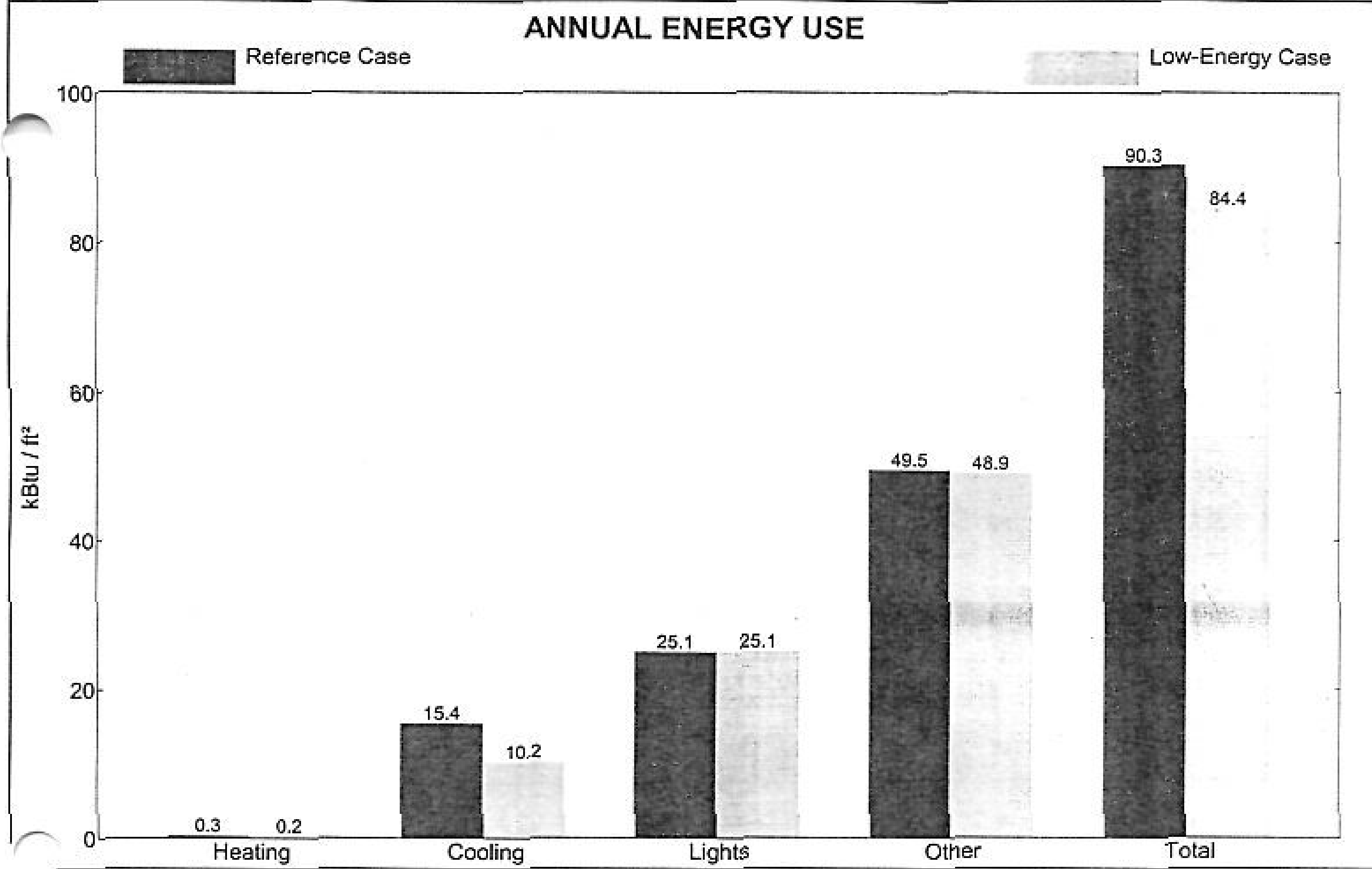
Description:	Reference Case	Low-Energy Case
r Area, ft²	72000.0	72000.0
urface Area, ft²	515295.0	515295.0
Volume, ft³	1080000.0	1080000.0
Surface Area Ratio	8.16	8.16
Total Conduction UA, Btu/h-F	15322.1	15322.1
Average U-value, Btu/hr-ft²-F	0.030	0.030
Wall Construction	steelstud 4, R=43.5	steelstud 4, R=43.5
Roof Construction	flat, r-19, R=21.0	flat, r-19, R=21.0
Floor type, insulation	Slab on Grade, Reff=73.0	Slab on Grade, Reff=73.0
Window Construction	4060 double, alum, U=0.70	4060 double, alum, U=0.70
Window Shading	None	None
Wall total gross area, ft²	371295	371295
Roof total gross area, ft²	72000	72000
Ground total gross area, ft²	72000	72000
Window total gross area, ft²	3360	3360
Windows (N/E/S/W:Roof)	34/37/26/43:0	34/37/26/43:0
Glazing name	double, U=0.49	double, U=0.49

Operating parameters for zone 1		
HVAC system	PTAC AA Heat Pump/ER Backup	PTAC AA Heat Pump/ER Backup
Rated Output (Heat/SCool/TCool),kBtuh	1068/1509/2012	1076/1499/1998
Rated Air Flow/MOOA,cfm	98514/0	98537/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	78.0 °F, no setup	78.0 °F, no setup
Heat/cool performance	COP=3.3,EER=10.0	COP=4.5,EER=15.0
Economizer?/type	no/NA	no/NA
leaks/conduction losses, total %	0/0	0/0
eak Gains; IL,EL,HW,OT; W/ft²	2.00/0.05/0.36/3.00	2.00/0.05/0.36/3.00
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ELA=2185.4	ELA=2185.4

Results: (Energy cost: 0.400 $/Therm, 0.054 $/kWh, 2.470 $/kW)

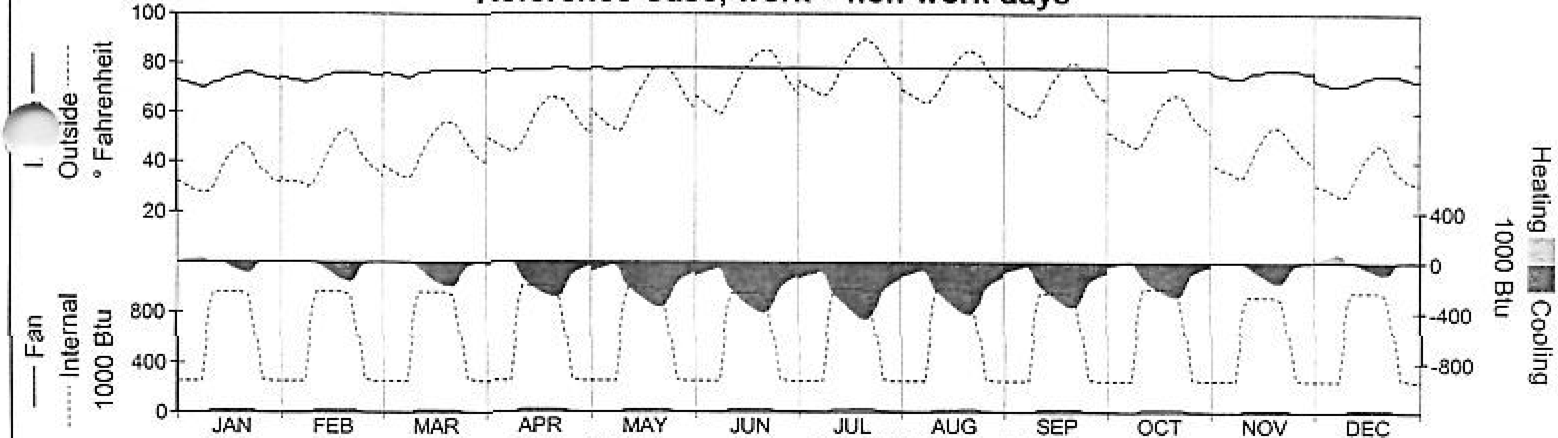
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Simulation status, Thermal/DL	valid/NA	valid/NA
Energy use, kBtu	6499127	6078905
Energy cost, $	117400	109389
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	1904618	1781469
Internal/External lights, kWh	514483/14717	514483/14717
Heating/Cooling/Fan, kWh	6436/325411/27048	4664/214840/16241
Elec. Res./Heat Pump, kWh	6429/7	4657/7
Hot water/Other, kWh	109756/906768	109756/906768
Peak Electric, kW	540.9	478.6
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	2559806/15046/7809	2394294/14074/7304

st michaels / AutoBuild Shoebox



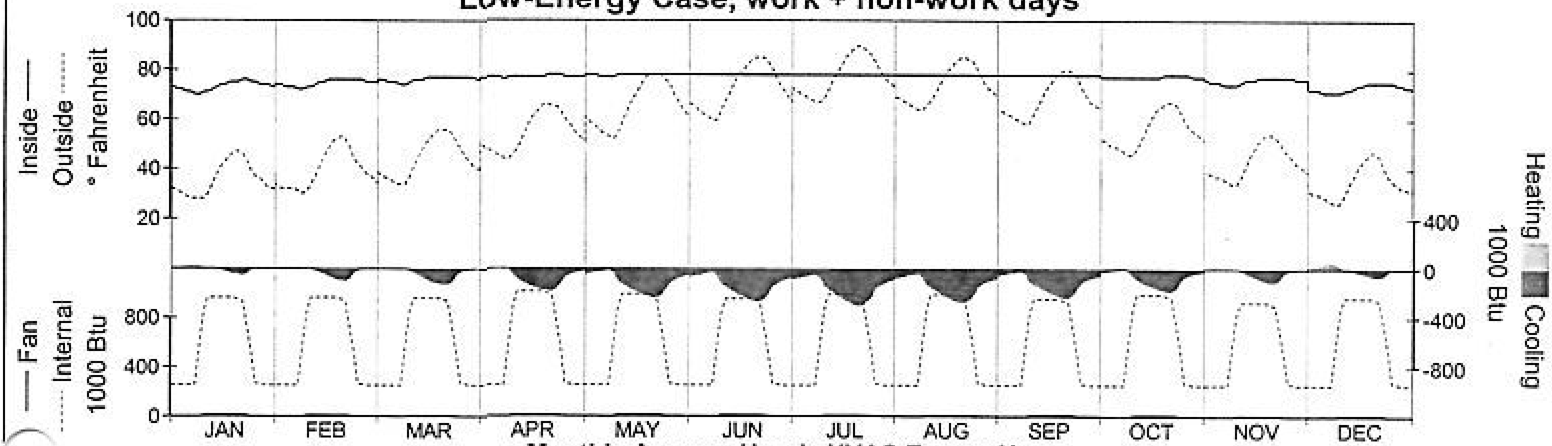
st michaels / AutoBuild Shoebox

Reference Case, work + non-work days



Monthly Average Hourly HVAC Energy Use

Low-Energy Case, work + non-work days

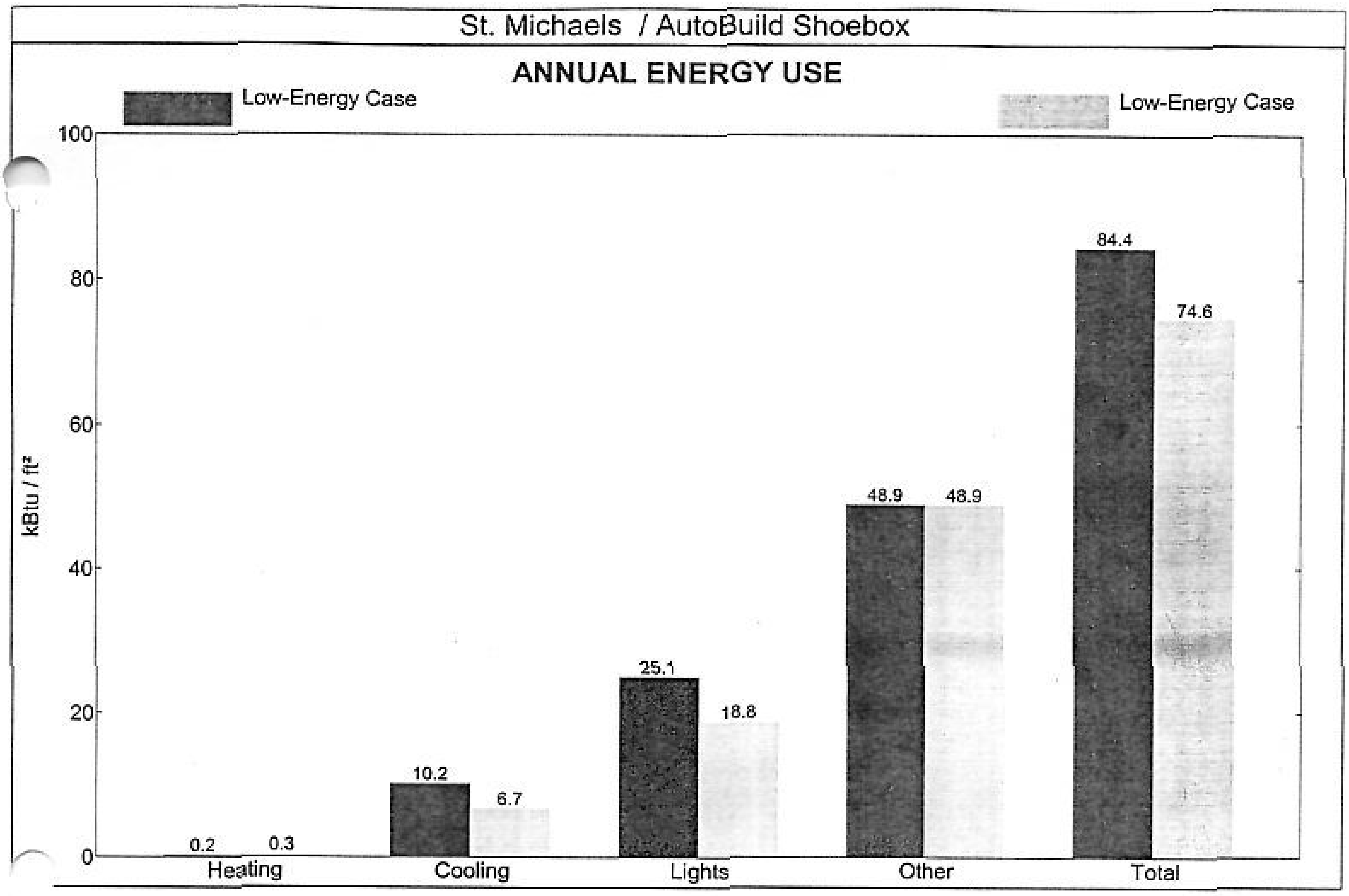


Monthly Average Hourly HVAC Energy Use

St. Michaels
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments:

May 12, 2001
Weather file: albqrque.et1
Saved as X:\ENERGY10, Var.+ S

Description:	Low-Energy Case	Low-Energy Case
..r Area, ft²	72000.0	72000.0
.. ..face Area, ft²	515295.0	515295.0
Volume, ft³	1080000.0	1080000.0
Surface Area Ratio	8.16	8.16
Total Conduction UA, Btu/h-F	15322.1	15322.1
Average U-value, Btu/hr-ft²-F	0.030	0.030
Wall Construction	steelstud 4, R=43.5	steelstud 4, R=43.5
Roof Construction	flat, r-19, R=21.0	flat, r-19, R=21.0
Floor type, insulation	Slab on Grade, Reff=73.0	Slab on Grade, Reff=73.0
Window Construction	4060 double, alum, U=0.70	4060 double, alum, U=0.70
Window Shading	None	None
Wall total gross area, ft²	371295	371295
Roof total gross area, ft²	72000	72000
Ground total gross area, ft²	72000	72000
Window total gross area, ft²	3360	3360
Windows (N/E/S/W:Roof)	34/37/26/43:0	34/37/26/43:0
Glazing name	double, U=0.49	double, U=0.49
Operating parameters for zone 1		
HVAC system	PTAC AA Heat Pump/ER Backup	PTAC AA Heat Pump/ER Backup
Rated Output (Heat/SCool/TCool),kBtuh	1076/1499/1998	1264/1439/1919
Rated Air Flow/MOOA,cfm	98537/0	92672/0
Heating thermostat	68.0 °F, no setback	68.0 °F, setback to 63.0 °F
Cooling thermostat	78.0 °F, no setup	78.0 °F, setup to 83.0 °F
Heat/cool performance	COP=4.5,EER=15.0	COP=4.5,EER=15.0
Economizer?/type	no/NA	yes/fixed dry bulb, 60.0 °F
leaks/conduction losses, total %	0/0	0/0
.. ..k Gains; IL,EL,HW,OT; W/ft²	2.00/0.05/0.36/3.00	1.50/0.04/0.36/3.00
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ELA=2185.4	ELA=1500.0
Results: (Energy cost: 0.400 $/Therm, 0.054 $/kWh, 2.470 $/kW)		
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Simulation status, Thermal/DL	valid/NA	valid/NA
Energy use, kBtu	6078905	5374008
Energy cost, $	109389	97488
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	1781469	1574893
Internal/External lights, kWh	514483/14717	385862/11038
Heating/Cooling/Fan, kWh	4664/214840/16241	6243/140955/14271
Elec. Res./Heat Pump, kWh	4657/7	5648/596
Hot water/Other, kWh	109756/906768	109756/906768
Peak Electric, kW	478.6	452.7
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	2394294/14074/7304	2116656/12442/6457


St. Michaels / AutoBuild Shoebox
ANNUAL ENERGY USE
Low-Energy Case
Low-Energy Case
kBtu / ft²
100
80
60
40
20
0
0.2
0.3
10.2
6.7
25.1
18.8
48.9
48.9
84.4
74.6
Heating
Cooling
Lights
Other
Total

St. Michaels
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments:

May 12, 2001
Weather file: albqrque.etl
Saved as X:\ENERGY10, Var. 3

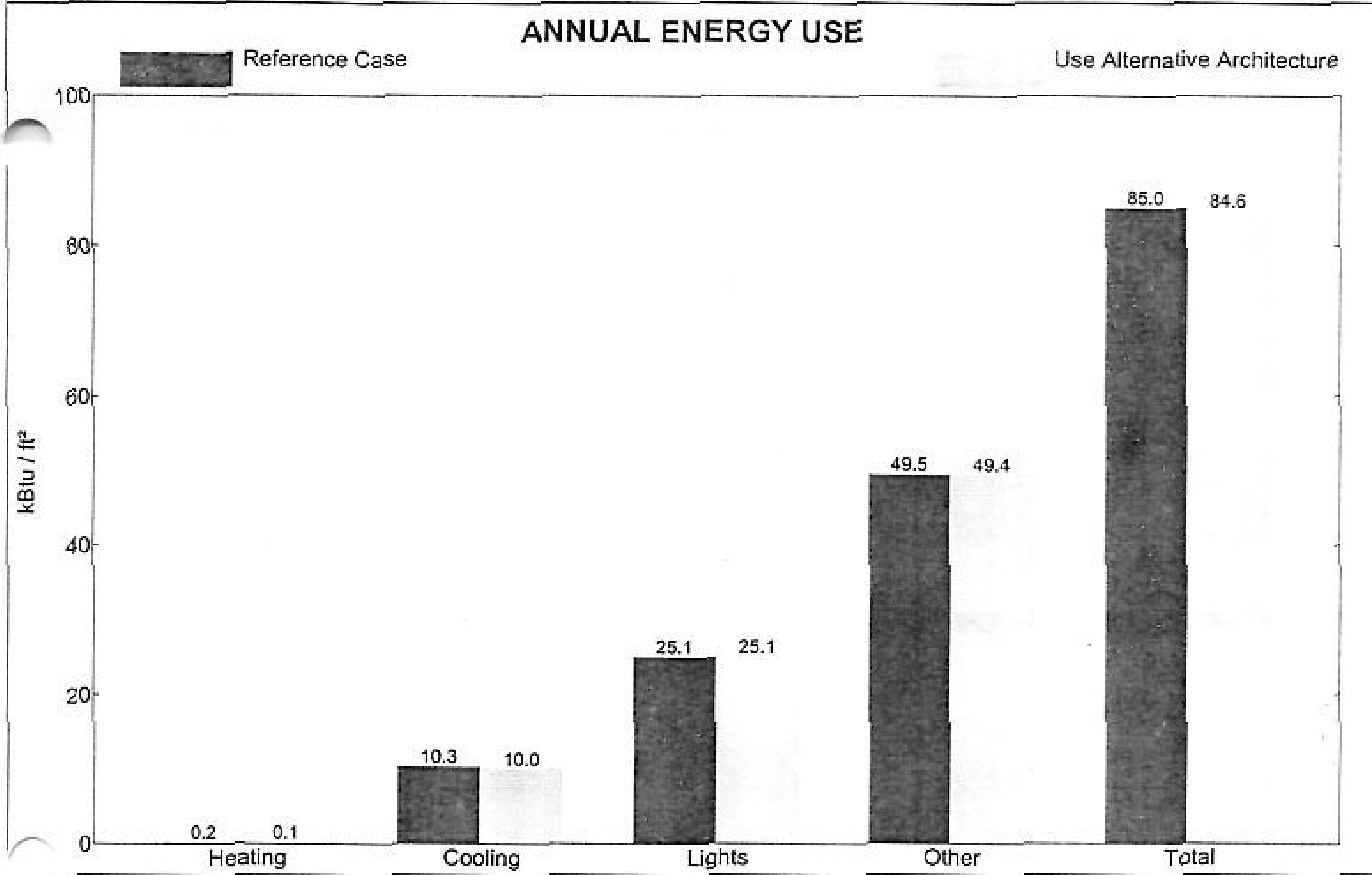
Description:	Reference Case	Use Alternative Architecture
r Area, ft^2	72000.0	72000.0
Surface Area, ft^2	515295.0	515295.0
Volume, ft^3	1080000.0	1080000.0
Surface Area Ratio	8.16	8.16
Total Conduction UA, Btu/h-F	15322.1	14011.7
Average U-value, Btu/hr-ft^2-F	0.030	0.027
Wall Construction	steelstud 4, R=43.5	steelstud 4, R=43.5
Roof Construction	flat, r-19, R=21.0	flat, r-19, R=21.0
Floor type, insulation	Slab on Grade, Reff=73.0	Slab on Grade, Reff=73.0
Window Construction	4060 double, alum, U=0.70	4060 low-e al/b, U=0.31,etc
Window Shading	None	52 deg latitude
Wall total gross area, ft^2	371295	371295
Roof total gross area, ft^2	72000	72000
Ground total gross area, ft^2	72000	72000
Window total gross area, ft^2	3360	3360
Windows (N/E/S/W:Roof)	34/37/26/43:0	34/37/26/43:0
Glazing name	double, U=0.49	**double low-e, U=0.26**

Operating parameters for zone 1		
HVAC system	PTAC AA Heat Pump/ER Backup	PTAC AA Heat Pump/ER Backup
Rated Output (Heat/SCool/TCool),kBtuh	1068/1509/2012	1002/1437/1917
Rated Air Flow/MOOA,cfm	98514/0	93211/0
Heating thermostat	68.0 °F, no setback	68.0 °F, no setback
Cooling thermostat	78.0 °F, no setup	78.0 °F, no setup
Heat/cool performance	COP=4.5,EER=15.0	COP=4.5,EER=15.0
Economizer?/type	no/NA	no/NA
leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft^2	2.00/0.05/0.36/3.00	2.00/0.05/0.36/3.00
Added mass?	none	none
Daylighting?	no	no
Infiltration, in^2	ELA=2185.4	ELA=2185.4

Results: (Energy cost: 0.400 \$/Therm, 0.054 \$/kWh, 2.470 \$/kW)

Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Simulation status, Thermal/DL	valid/NA	valid/NA
Energy use, kBtu	6122522	6090450
Energy cost, \$	110190	109549
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	1794251	1784852
Internal/External lights, kWh	514483/14717	514483/14717
Heating/Cooling/Fan, kWh	4539/216940/27048	2569/210959/25600
Elec. Res./Heat Pump, kWh	4532/7	2565/4
Hot water/Other, kWh	109756/906768	109756/906768
Peak Electric, kW	482.6	476.3
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	2411473/14175/7356	2398841/14100/7318

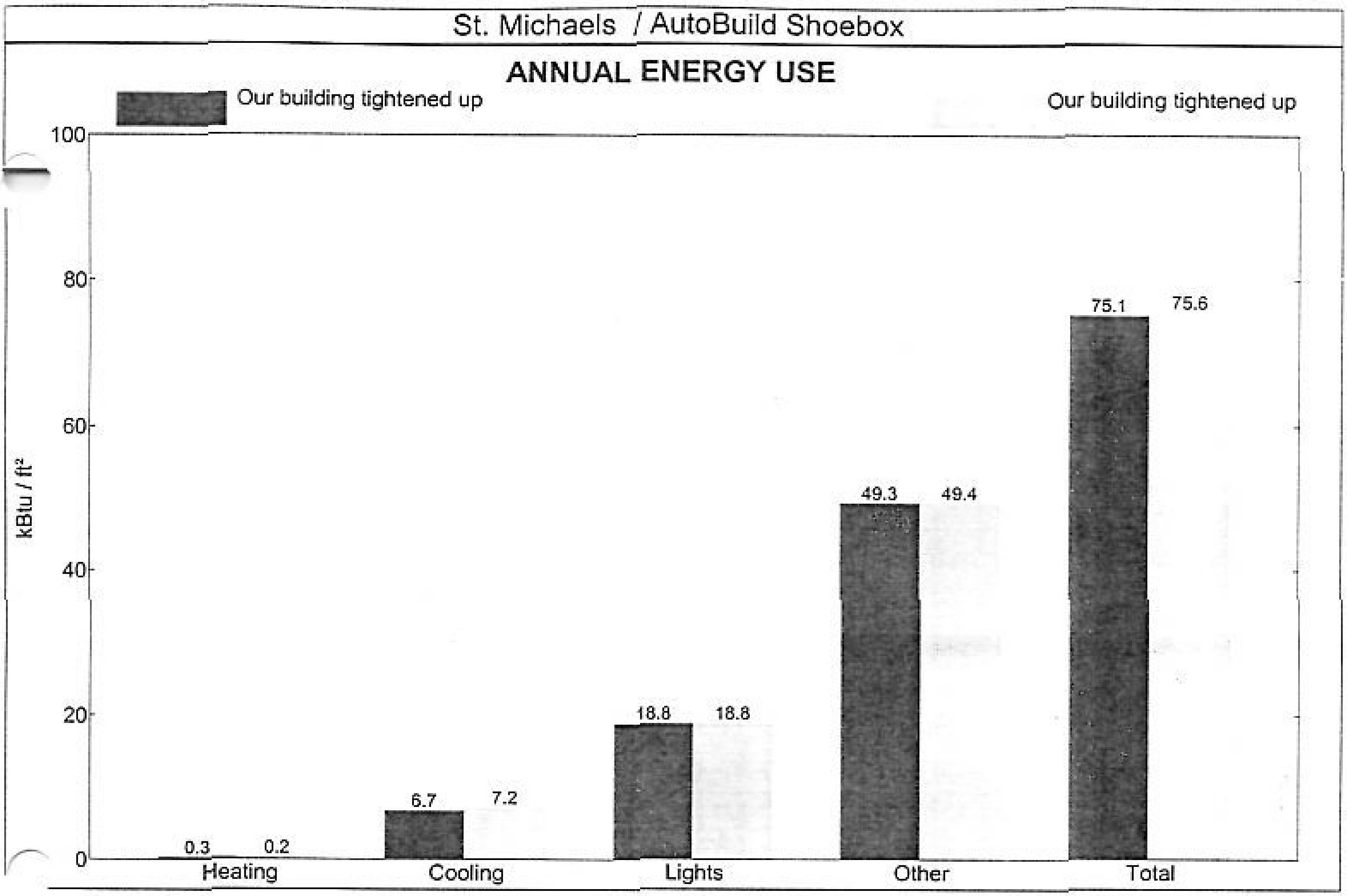
St. Michaels / AutoBuild Shoebox



St. Michaels
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments:

May 12, 2001
Weather file: albqrque.et1
Saved as X:\ENERGY10, Var. 2

Description:	Our building tightened up	Our building tightened up
r Area, ft²	72000.0	72000.0
. face Area, ft²	515295.0	515295.0
Volume, ft³	1080000.0	1080000.0
Surface Area Ratio	8.16	8.16
Total Conduction UA, Btu/h-F	15322.1	15345.6
Average U-value, Btu/hr-ft²-F	0.030	0.030
Wall Construction	steelstud 4, R=43.5	steelstud 4, R=43.5
Roof Construction	flat, r-19, R=21.0	flat, r-19, R=21.0
Floor type, insulation	Slab on Grade, Reff=73.0	Slab on Grade, Reff=73.0
Window Construction	4060 double, alum, U=0.70	6060 double, low e, U=0.48,etc
Window Shading	None	None
Wall total gross area, ft²	371295	371295
Roof total gross area, ft²	72000	72000
Ground total gross area, ft²	72000	72000
Window total gross area, ft²	3360	5040
Windows (N/E/S/W:Roof)	34/37/26/43:0	34/37/26/43:0
Glazing name	double, U=0.49	double, U=0.49
Operating parameters for zone 1		
HVAC system	PTAC AA Heat Pump/ER Backup	PTAC AA Heat Pump/ER Backup
Rated Output (Heat/SCool/TCool),kBtuh	1255/1448/1931	1271/1512/2016
Rated Air Flow/MOOA,cfm	92651/0	96710/0
Heating thermostat	68.0 °F, setback to 63.0 °F	68.0 °F, setback to 63.0 °F
Cooling thermostat	78.0 °F, setup to 83.0 °F	78.0 °F, setup to 83.0 °F
Heat/cool performance	COP=4.5,EER=15.0	COP=4.5,EER=15.0
Economizer?/type	yes/fixed dry bulb, 60.0 °F	yes/fixed dry bulb, 60.0 °F
leaks/conduction losses, total %	0/0	0/0
. .c Gains; IL,EL,HW,OT; W/ft²	1.50/0.04/0.36/3.00	1.50/0.04/0.36/3.00
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ELA=1500.0	ELA=1500.0
Results: (Energy cost: 0.400 $/Therm, 0.054 $/kWh, 2.470 $/kW)		
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Simulation status, Thermal/DL	valid/NA	valid/NA
Energy use, kBtu	5410165	5444208
Energy cost, $	98153	98786
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	1585489	1595466
Internal/External lights, kWh	385862/11038	385862/11773
Heating/Cooling/Fan, kWh	6019/142281/23766	4713/151697/24896
Elec. Res./Heat Pump, kWh	5462/558	4353/360
Hot water/Other, kWh	109756/906768	109756/906768
Peak Electric, kW	456.3	461.4
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	2130898/12525/6501	2144306/12604/6541


St. Michaels / AutoBuild Shoebox
ANNUAL ENERGY USE
Our building tightened up
Our building tightened up
kBtu / ft²
100
80
60
40
20
0
0.3
0.2
6.7
7.2
18.8
18.8
49.3
49.4
75.1
75.6
Heating
Cooling
Lights
Other
Total

St. Michaels
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments:

May 11, 2001
Weather file: albqrque.et1
Saved as X:\ENERGY10, Var. 2

Description:	Reference Case	Our building tightened up
[illegible] Area, ft²	72000.0	72000.0
[illegible]face Area, ft²	515295.0	515295.0
Volume, ft³	1080000.0	1080000.0
Surface Area Ratio	8.16	8.16
Total Conduction UA, Btu/h-F	15322.1	15322.1
Average U-value, Btu/hr-ft²-F	0.030	0.030
Wall Construction	steelstud 4, R=43.5	steelstud 4, R=43.5
Roof Construction	flat, r-19, R=21.0	flat, r-19, R=21.0
Floor type, insulation	Slab on Grade, Reff=73.0	Slab on Grade, Reff=73.0
Window Construction	4060 double, alum. U=0.70	4060 double, alum, U=0.70
Window Shading	None	None
Wall total gross area, ft²	371295	371295
Roof total gross area, ft²	72000	72000
Ground total gross area, ft²	72000	72000
Window total gross area, ft²	3360	3360
Windows (N/E/S/W:Roof)	34/37/26/43:0	34/37/26/43:0
Glazing name	double, U=0.49	double, U=0.49
Operating parameters for zone 1		
HVAC system	PTAC AA Heat Pump/ER Backup	PTAC AA Heat Pump/ER Backup
Rated Output (Heat/SCool/TCool),kBtuh	1068/1509/2012	1255/1448/1931
Rated Air Flow/MOOA,cfm	98514/0	92651/0
Heating thermostat	68.0 °F, no setback	68.0 °F, setback to 63.0 °F
Cooling thermostat	78.0 °F, no setup	78.0 °F, setup to 83.0 °F
Heat/cool performance	COP=4.5,EER=15.0	COP=4.5,EER=15.0
Economizer?/type	no/NA	yes/fixed dry bulb, 60.0 °F
[illegible] leaks/conduction losses, total %	0/0	0/0
[illegible]ak Gains; IL,EL,HW,OT; W/ft²	2.00/0.05/0.36/3.00	1.50/0.04/0.36/3.00
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ELA=2185.4	ELA=1500.0
Results: (Energy cost: 0.400 $/Therm, 0.054 $/kWh, 2.470 $/kW)		
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Simulation status, Thermal/DL	valid/NA	valid/NA
Energy use, kBtu	6122522	5410165
Energy cost, $	110190	98153
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	1794251	1585489
Internal/External lights, kWh	514483/14717	385862/11038
Heating/Cooling/Fan, kWh	4539/216940/27048	6019/142281/23766
Elec. Res./Heat Pump, kWh	4532/7	5462/558
Hot water/Other, kWh	109756/906768	109756/906768
Peak Electric, kW	482.6	456.3
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	2411473/14175/7356	2130898/12525/6501

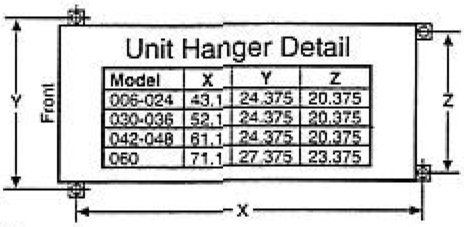
L. Equipment Cut Sheets

Refer to subsequent pages.

Genesis GR Physical Dimensions

Horizontal Dimensions

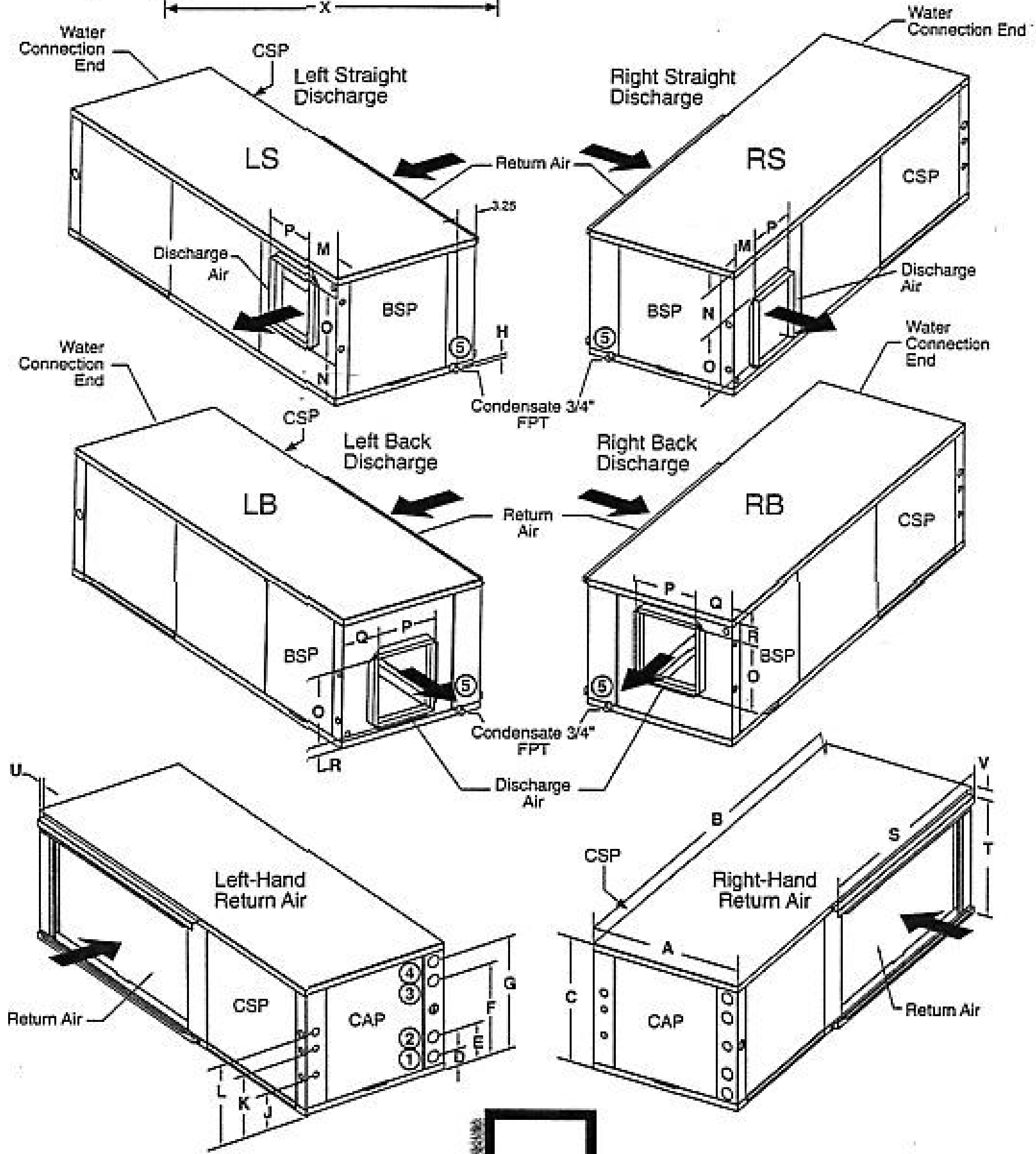
GR HORIZ MODEL		OVERALL CABINET			WATER CONNECTIONS*							ELECTRICAL KNOCKOUTS			DISCHARGE CONNECTION						RETURN CONNECTION			
					1	2	3	4	5															
		A WIDTH	B DEPTH	C HEIGHT	D IN	E OUT	F HWG IN	G HWG OUT	H CONDENSATE	LOOP WATER FPT	HWG FPT	J LOW VOLTAGE	K	L POWER SUPPLY	M	N	O SUPPLY WIDTH	P SUPPLY DEPTH	Q	R	S RETURN DEPTH	T RETURN HEIGHT	U	V
006-012	IN	22.4	43.1	11.3	2.4	5.4	N/A	N/A	0.6	0.5	0.5	3.5	5.5	8.0	5.8	4.0	5.8	8.0	5.8	1.5	20.0	8.0	1.0	1.0
015-024	IN	22.4	43.1	17.3	2.4	5.4	11.9	14.9	0.6	0.75	0.5	3.5	7.5	10.0	5.0	5.4	10.4	9.4	5.0	1.5	20.0	14.0	1.0	1.0
030	IN	22.4	52.1	19.3	2.4	5.4	13.9	16.9	0.6	0.75	0.5	6.0	9.5	12.0	5.0	6.8	10.4	9.4	5.0	2.1	22.1	17.0	2.5	1.0
036	IN	22.4	52.1	19.3	2.4	5.4	13.9	16.9	0.6	0.75	0.5	6.0	9.5	12.0	2.9	3.8	13.5	13.1	2.9	1.9	22.1	17.0	2.5	1.0
042-048	IN	22.4	61.1	19.3	2.4	5.4	13.9	16.9	0.6	1.0	0.5	6.0	9.5	12.0	2.9	3.8	13.5	13.1	2.9	1.9	31.1	17.0	3.5	1.0
060	IN	25.4	71.1	21.3	2.4	5.4	15.9	18.9	0.6	1.0	0.5	8.0	11.5	14.0	5.8	5.0	13.5	13.1	5.8	2.9	36.1	19.0	2.5	1.0



Unit Hanger Detail

Model	X	Y	Z
006-024	43.1	24.375	20.375
030-036	52.1	24.375	20.375
042-048	61.1	24.375	20.375
060	71.1	27.375	23.375

CAP=Control Access Panel
CSP=Compressor Service Panel
BSP=Blower Service Panel



Performance Data GRH/GRV 060

Table does not reflect fan or pump power ISO corrections

* ISO Certified @ 59,000 Btuh and 12.8 EER in cooling and 68,000 Btuh and 4.2 COP in heating.

2000 CFM Nominal Airflow

Performance capacities shown in thousands

EWT °F	GPM	WPD		COOLING - EAT 80.6/66.2 °F						HEATING - EAT 68°F				
		PSI	FT	TC	SC	Sens/Tot Ratio	KW	HR	EER	HC	KW	HE	LAT	COP
20	7.5	3.0	7.0	Operation Not Recommended										
	11.3	5.9	13.6											
	15.0	9.7	22.4							38.7	3.87	25.5	87.9	2.93
30	7.5	2.9	6.8	54.0	40.0	0.74	3.28	65.2	16.4	43.3	3.93	29.9	90.1	3.23
	11.3	5.7	13.2	54.1	40.2	0.74	3.18	65.0	17.0	44.0	3.97	30.5	90.4	3.25
	15.0	9.4	21.7	54.3	40.3	0.74	3.07	64.8	17.7	44.7	4.00	31.1	90.7	3.27
40	7.5	2.8	6.5	62.3	47.2	0.76	3.63	74.7	17.2	49.5	4.07	35.6	92.9	3.56
	11.3	5.5	12.7	62.5	47.4	0.76	3.51	74.5	17.8	50.3	4.11	36.3	93.3	3.59
	15.0	9.1	20.9	62.6	47.5	0.76	3.39	74.2	18.5	51.1	4.15	37.0	93.7	3.61
50	7.5	2.7	6.3	65.0	50.1	0.77	3.92	78.4	16.6	56.1	4.24	41.6	96.0	3.88
	11.3	5.3	12.3	65.2	50.3	0.77	3.80	78.2	17.2	57.0	4.28	42.4	96.4	3.91
	15.0	8.7	20.2	65.4	50.4	0.77	3.67	77.9	17.8	57.9	4.31	43.2	96.8	3.93
60	7.5	2.6	6.1	64.6	50.4	0.78	4.20	78.9	15.4	62.8	4.41	47.7	99.1	4.17
	11.3	5.1	11.8	64.8	50.6	0.78	4.07	78.6	15.9	63.7	4.45	48.6	99.5	4.19
	15.0	8.4	19.4	64.9	50.7	0.78	3.93	78.3	16.5	64.7	4.49	49.4	100.0	4.22
70	7.5	2.5	5.8	62.7	49.6	0.79	4.49	78.0	14.0	68.9	4.58	53.3	101.9	4.41
	11.3	4.9	11.4	62.9	49.7	0.79	4.35	77.7	14.5	70.0	4.62	54.2	102.4	4.44
	15.0	8.1	18.7	63.0	49.9	0.79	4.20	77.4	15.0	71.1	4.67	55.2	102.9	4.46
80	7.5	2.5	5.7	60.5	48.3	0.80	4.82	77.0	12.5	73.7	4.72	57.6	104.1	4.58
	11.3	4.8	11.1	60.7	48.5	0.80	4.66	76.6	13.0	74.9	4.76	58.7	104.7	4.61
	15.0	7.9	18.2	60.8	48.6	0.80	4.51	76.2	13.5	76.1	4.80	59.7	105.2	4.64
90	7.5	2.4	5.5	58.4	47.2	0.81	5.21	76.1	11.2	76.0	4.77	59.7	105.2	4.67
	11.3	4.7	10.8	58.5	47.3	0.81	5.04	75.7	11.6	77.2	4.82	60.8	105.8	4.70
	15.0	7.7	17.7	58.7	47.4	0.81	4.87	75.3	12.1	78.4	4.86	61.8	106.3	4.73
100	7.5	2.3	5.4	56.1	45.9	0.82	5.66	75.4	9.9	Operation Not Recommended				
	11.3	4.5	10.5	56.2	46.1	0.82	5.48	74.9	10.3					
	15.0	7.5	17.3	56.4	46.2	0.82	5.29	74.4	10.6					
110	7.5	2.3	5.2	52.7	44.1	0.84	6.19	73.8	8.5					
	11.3	4.4	10.2	52.8	44.3	0.84	5.99	73.3	8.8					
	15.0	7.3	16.8	53.0	44.4	0.84	5.79	72.7	9.1					

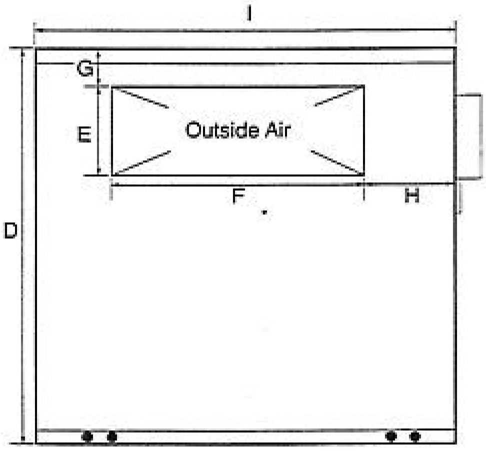
Interpolation is permissable. Extrapolation is not.

All entering air conditions are 80.6 °F DB and 66.2°F WB in cooling and 68°F DB and 59°F WB in heating

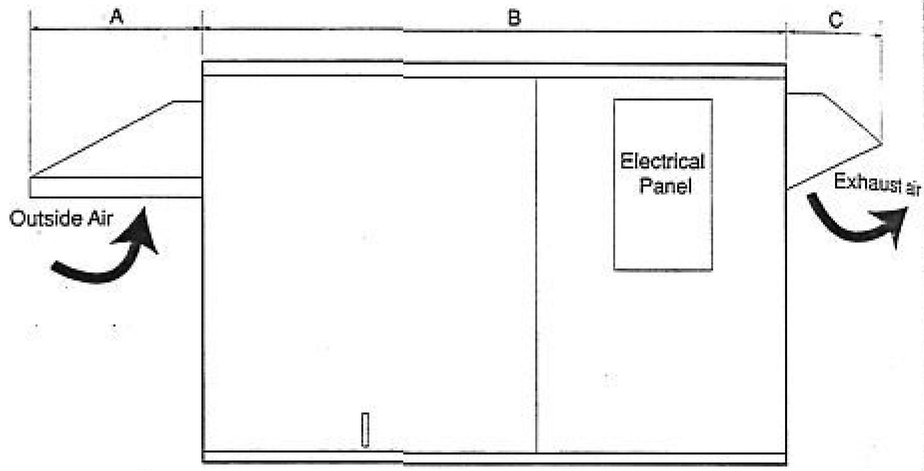
All performance data is based upon the lower voltage of dual voltage rated units

* ISO Certified conditions are 86 °F EWT, 80.6 °F DB and 66.2 °F WB in cooling and 68°F EWT, 68 °F DB and 59°F WB in heating.
  Operation below 60°F EWT requires optional insulated water circuit.
  See Performance Data Correction Tables for operation conditions other than those listed above.

Unit Arrangement V Series
Front & Left View



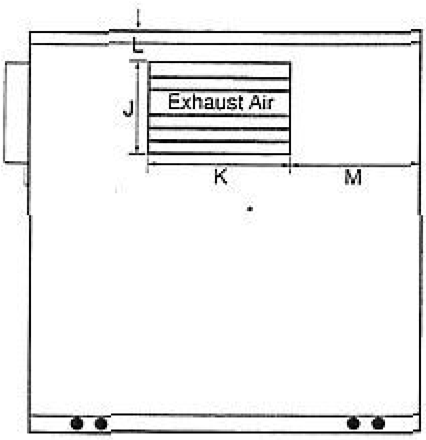
Left View



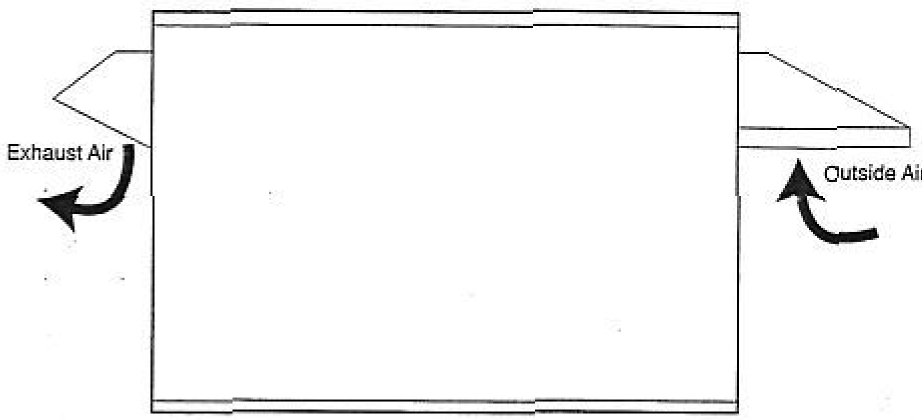
Front View

Model#	Net Weight (lbs.)	Dimensions (inches)								
		A	B	C	D	E	F	G	H	I
FV-1000V	500	16.3	44.4	8.7	31	8	23.1	2.4	2.9	29
FV-2000V	550	20.4	51.5	13.8	32.4	10.7	31.1	2.8	3	37
FV-3000V	1000	20.4	64.8	10.7	47.7	14.8	39	4.2	3.1	45
FV-5000V	1150	33	78.7	10.7	51.5	16.5	48	2.8	3.2	54

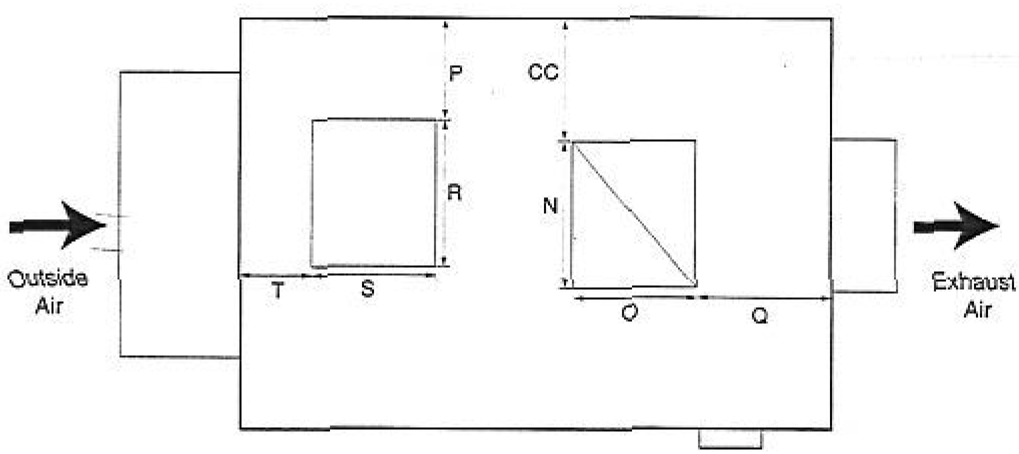
Unit Arrangement V Series
Back, Right & Bottom View



Right View



Back View



Bottom View

Model#	Net Wt. (lbs.)	Dimensions (inches)											
		J	K	L	M	N	O	P	Q	R	S	T	CC
FV-1000V	500	10.3	9.2	3.5	9.9	11.2	10	7	14.3	10.2	9.3	5.3	9
FV-2000V	550	11.4	13.1	5	12.5	23	7.8	7	18.5	10.3	11.8	4	7
FV-3000V	1000	11.4	13.1	10.5	16	24	12	7	16.7	11.4	13.1	7.4	7
FV-5000V	1150	15.9	18.6	9.3	17.6	20	19	7	20.7	15.9	18.6	5.2	12

FV-5000 Supply Fan Data

Airflow (scfm)	External Static Pressure (in.wg.)*								
	-0.3	-0.1	0.1	0.3	0.5	0.75	1.0	1.25	1.50
	Motor Brake Horsepower/RPM**								
2600	.15/288	.24/389	.36/488	.43/565	.63/639	.72/721	-	-	-
3000	.26/349	.39/440	.48/522	.62/598	.74/663	.89/737	1.14/810	-	-
3400	.41/420	.50/489	.64/561	.76/627	.90/687	1.10/757	1.32/830	1.52/901	1.71/963
3800	.61/468	.69/541	.81/602	1.00/661	1.17/717	1.37/785	1.55/853	1.79/917	2.01/979
4200	.78/518	.9/581	1.08/633	1.25/692	1.40/745	1.6/811	1.82/874	2.08/933	2.33/991
4600	1.03/568	1.18/624	1.39/676	1.52/729	1.72/781	1.89/844	2.19/895	2.47/945	2.71/1008
5000	1.29/592	1.48/650	1.64/696	1.81/751	2.00/793	2.21/869	2.55/922	2.84/976	-

Note: For power draw see standard motor in Table 6 on page 32.

Supplied Motor:

0.75 hp, 1725 rpm	1.50 hp, 1725 rpm
2.00 hp, 1725 rpm	3.00 hp, 1725 rpm

FV-5000 Exhaust Fan Data

Airflow (scfm)	External Static Pressure (in.wg.)*								
	-0.3	-0.1	0.1	0.3	0.5	0.75	1.0	1.25	1.50
	Motor Brake Horsepower/RPM**								
2600	.18/356	.29/450	.41/573	.54/614	.65/683	.84/760	-	-	-
3000	.32/418	.43/504	.62/579	.72/647	.81/708	1.03/781	1.23/857	-	-
3400	.49/485	.63/558	.75/624	.89/685	1.06/741	1.27/813	1.48/885	1.69/949	-
3800	.71/542	.83/605	1.02/664	1.18/720	1.32/774	1.50/842	1.76/907	1.98/969	2.17/1031
4200	.93/596	1.13/651	1.27/705	1.45/758	1.60/810	1.82/874	2.08/933	2.33/991	2.60/1049
4600	1.27/647	1.40/683	1.62/752	1.77/803	1.93/851	2.24/909	2.50/965	2.78/1021	-
5000	1.56/701	1.76/744	1.92/795	2.16/842	2.41/886	2.68/940	2.91/993	-	-

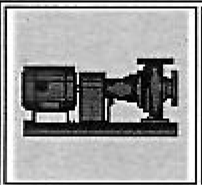
Note: For power draw see standard motor in Table 6 on page 32.

* Positive statics reference external static pressures that work against the FV unit fan. Negative statics would work with the FV unit fan. For example, an FV preconditioner that is blowing into a mixing section of another air handling unit (AHU) with a -0.3" static pressure in the AHU mixing section would have an FV supply fan static of -0.3" and an exhaust fan static of +0.3". All statics internal to the FV Unit are already included in the selection.

**Motors showing RPM are for belt drive.

Bell & Gossett
ITT Industries

ESP-PLUS
Pump Selection Results
Version $1.92



- 1510 Product Literature
- View Pump Specification
- Download 1510 Entire Curve Booklet (PDF File)

SUMMARY									
System Capacity = 330 GPM					Total Developed Head = 300 Feet				
Pump Series	Model	Speed (RPM)	Pump Efficiency	Duty Point (BHP)	Motor Size (HP)	Impeller Size(in)	Weight (lbs)	Cost Index	Quote Request
1510	2-1/2BB	3550	67.98	37.12	40	8.625	**	**	◉
1510	2BC	3550	65.64	38.16	40	8.875	**	**	○
1510	3BC	3500	56.15	44.47	50	8.625	**	**	○
1510	4BC	3550	46.71	54.09	60	8.875	**	**	○
Submit Quote Request									

** This information is only available in the enhanced version

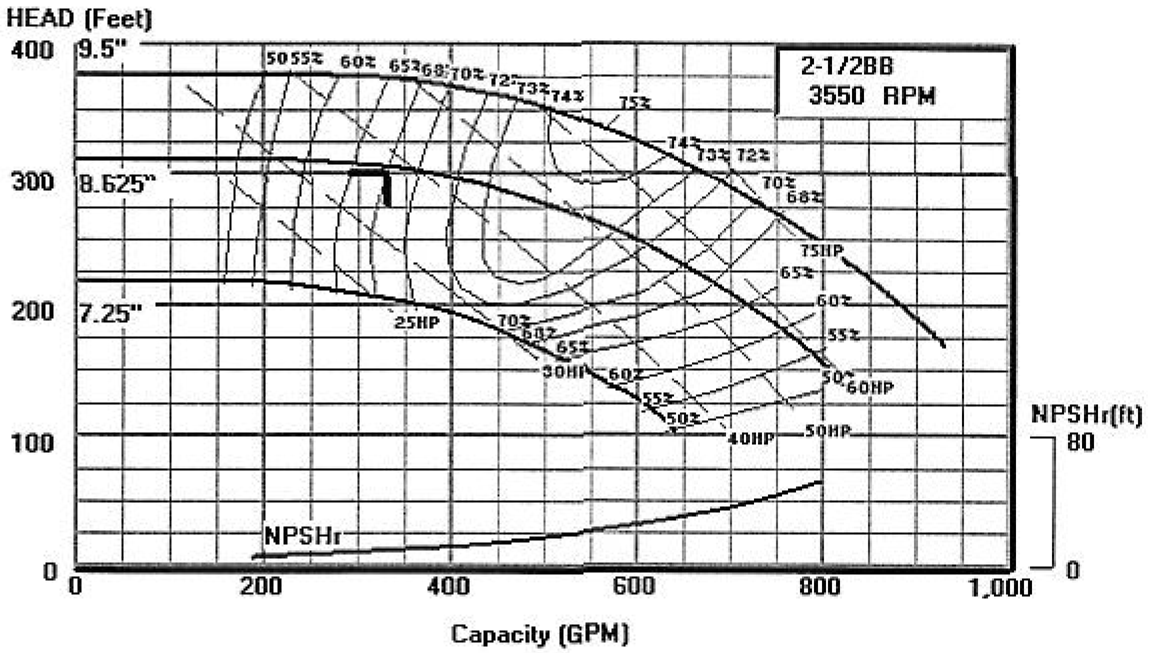
PUMP DETAILS

1510 2-1/2BB			
Flow Rate (GPM)	330	Pump Head (Feet)	300
Speed (RPM)	3550	NPSHr (Feet)	9.2
Weight (lbs)	**	Cost Index	**
Suction Size (in.)	3	Suction Velocity (fps)	14.3
Discharge Size (in.)	2-1/2	Discharge Velocity (fps)	22.1
Impeller Size (in.)	8.625	Pump Efficiency (%)	67.98
Max. Flow (GPM)	814	Duty Flow/Max Flow (%)	40.5
Flow @ BEP (GPM)	492	Min. Rec. Flow (GPM)	123.0
Selected Motor Size (HP)	40	Selected Motor Size (kw)	29.83
Duty-Point Power (BHP)	37.12	Duty-Point Power (kw)	27.68
Maximum Power (BHP)	56.87	Maximum Power (kw)	42.41
Motor Manufacturer	**	Full Load Amps	**

Bell & Gossett

ITT Industries

Curve Generation
Version C1.16



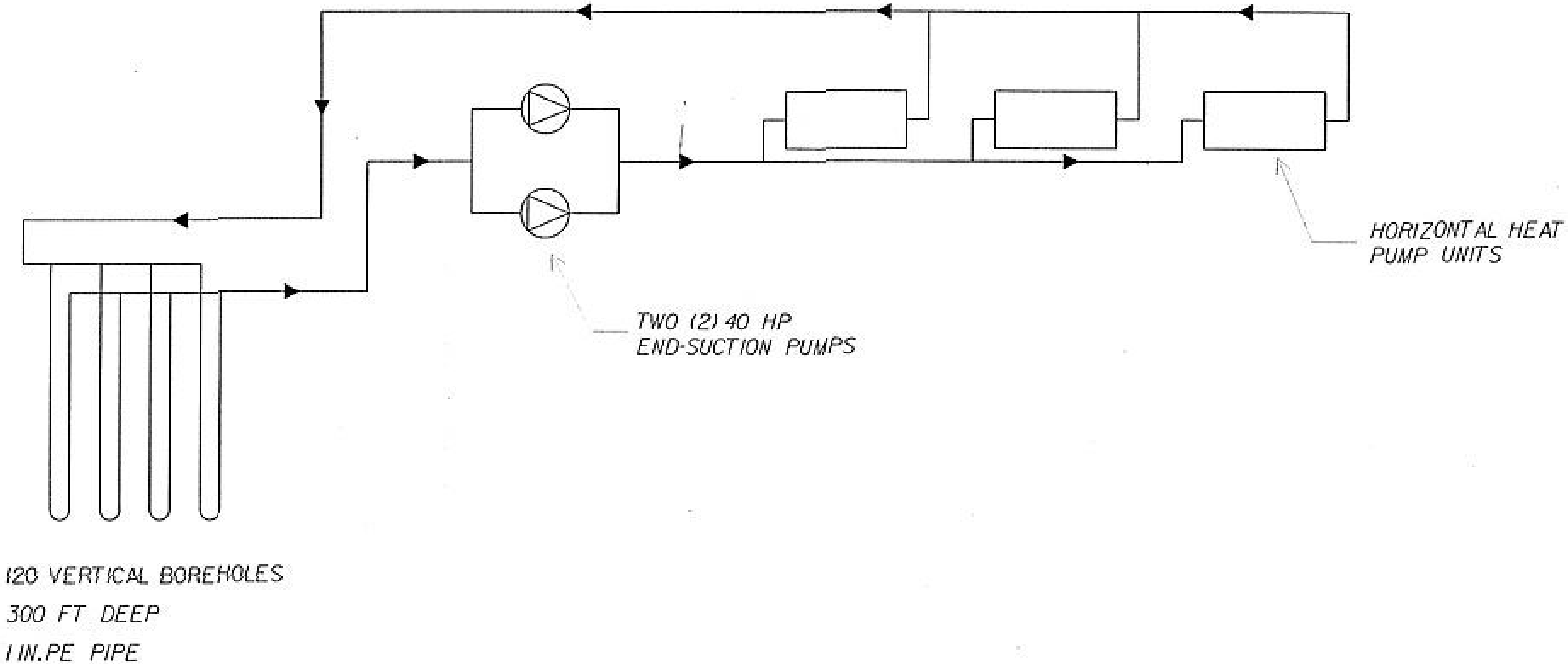
Pump Series: 1510	Min Imp Dia = 7.25 "	Design Capacity =330.0	ITT Bell & Gossett
Suction Size = 3 "	Max Imp Dia = 9.5 "	Design Head =300.0	8200 N. Austin
Discharge Size = 2.5 "	Cut Dia = 8.625 "	Motor Size =40 HP	Morton Grove, Il 60053

Generate Another Pump Curve

☑ Display Max/Min Imp. curves ☑ Display Efficiency Curve ☑ Display Power Curve ☑ Display NPSHr Curve	☑ Display Duty-Point Marker ☐ Display System Curve ☑ Display Minor Gridlines ☐ Display Dark Background
Single Pump Operation	
Constant Speed Operation	If Variable Speed (or Open System), Enter a Control Head (or Static Head) 0
Display results in ◉ English Units ○ Metric Units	

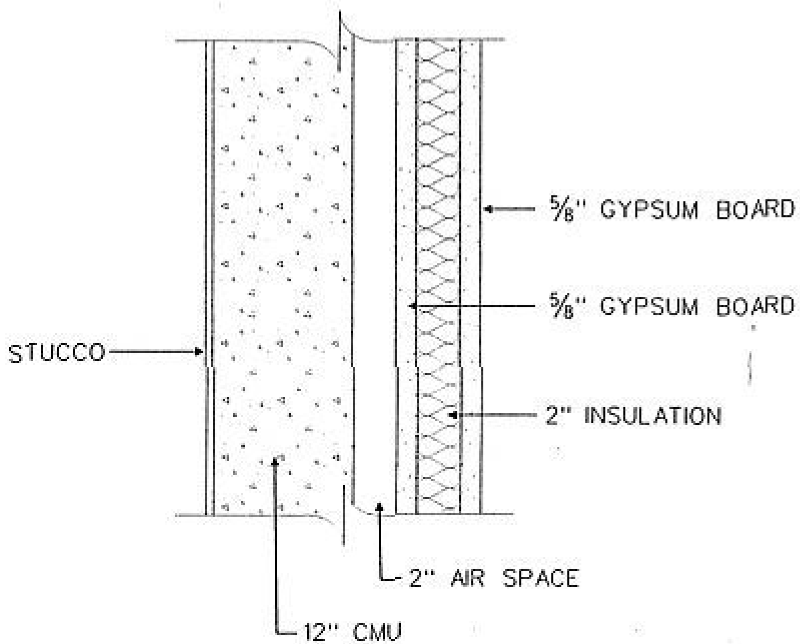
M. System Details

Refer to subsequent pages. (Note: all details with exception of Ground Source Heat Pump System Schematic and Envelope Construction Diagrams obtained courtesy of Burt Hill Kosar Rittelmann, Associates.)

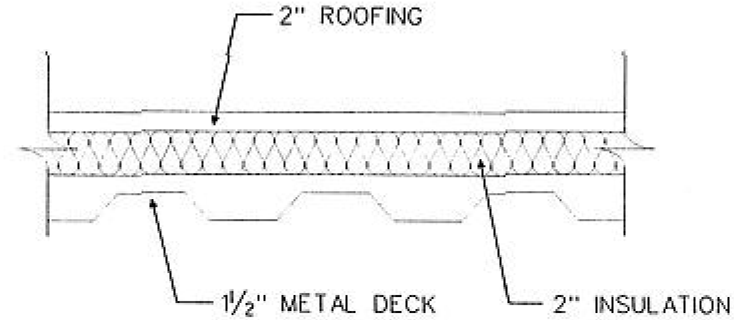


GROUND SOURCE HEAT PUMP SYSTEM SCHEMATIC

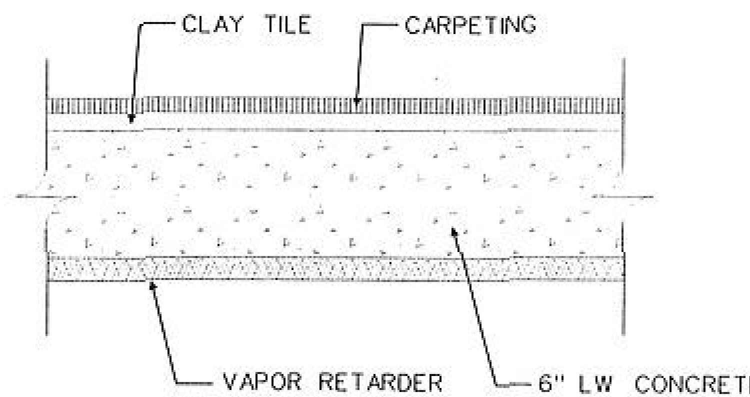
d:\dgn\alpbase.dgn Mar. 04, 2001 17:58:23



WALL CONSTRUCTION: U = 0.022982 BTU/hr.ft^2.°F



ROOF CONSTRUCTION: U = 0.04684 BTU/hr.ft^2.°F



FLOOR CONSTRUCTION: U = 0.143336 BTU/hr.ft^2.°F

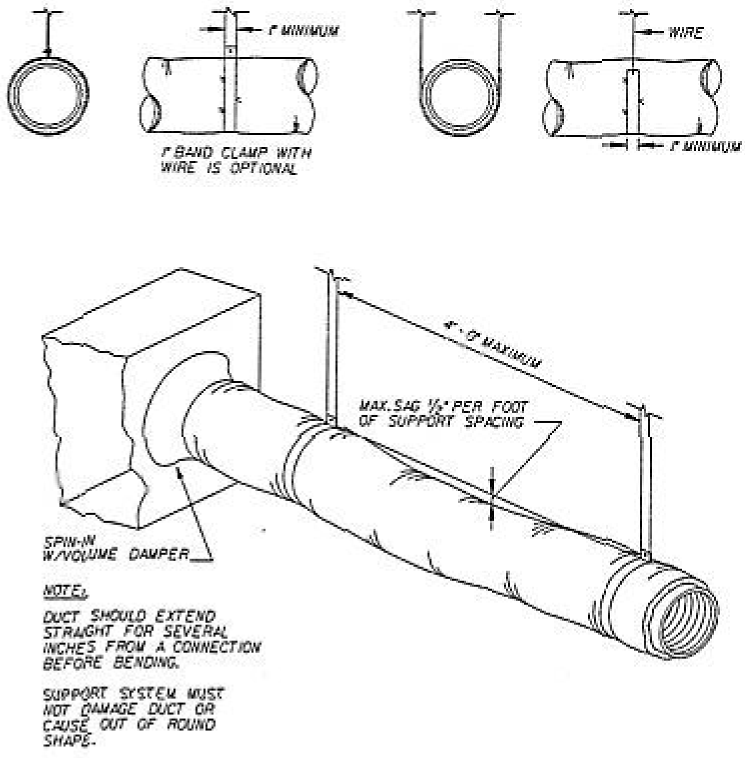
SMASE DESIGN PROJECT
WINDOW ROCK, ARIZONA

FBM DESIGN
DREXEL UNIVERSITY

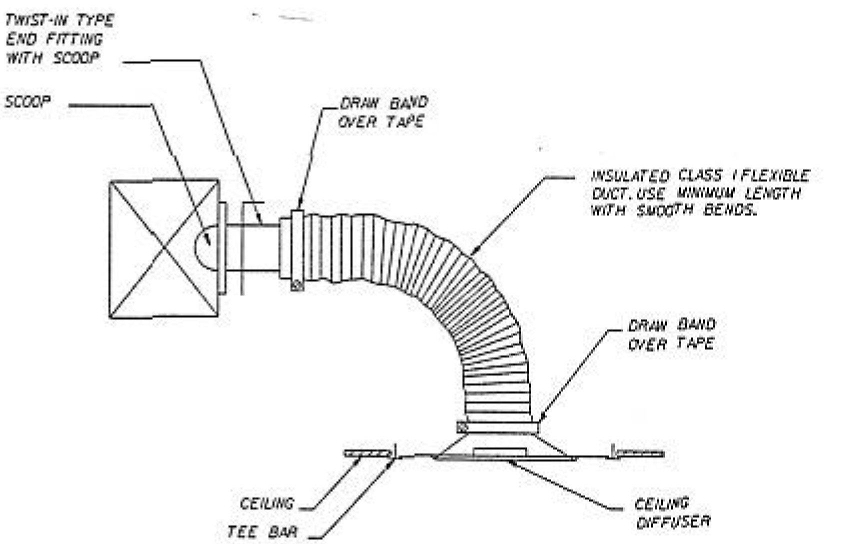
MARCH 8, 2001

ENVELOPE CONSTRUCTION DIAGRAMS
NO SCALE

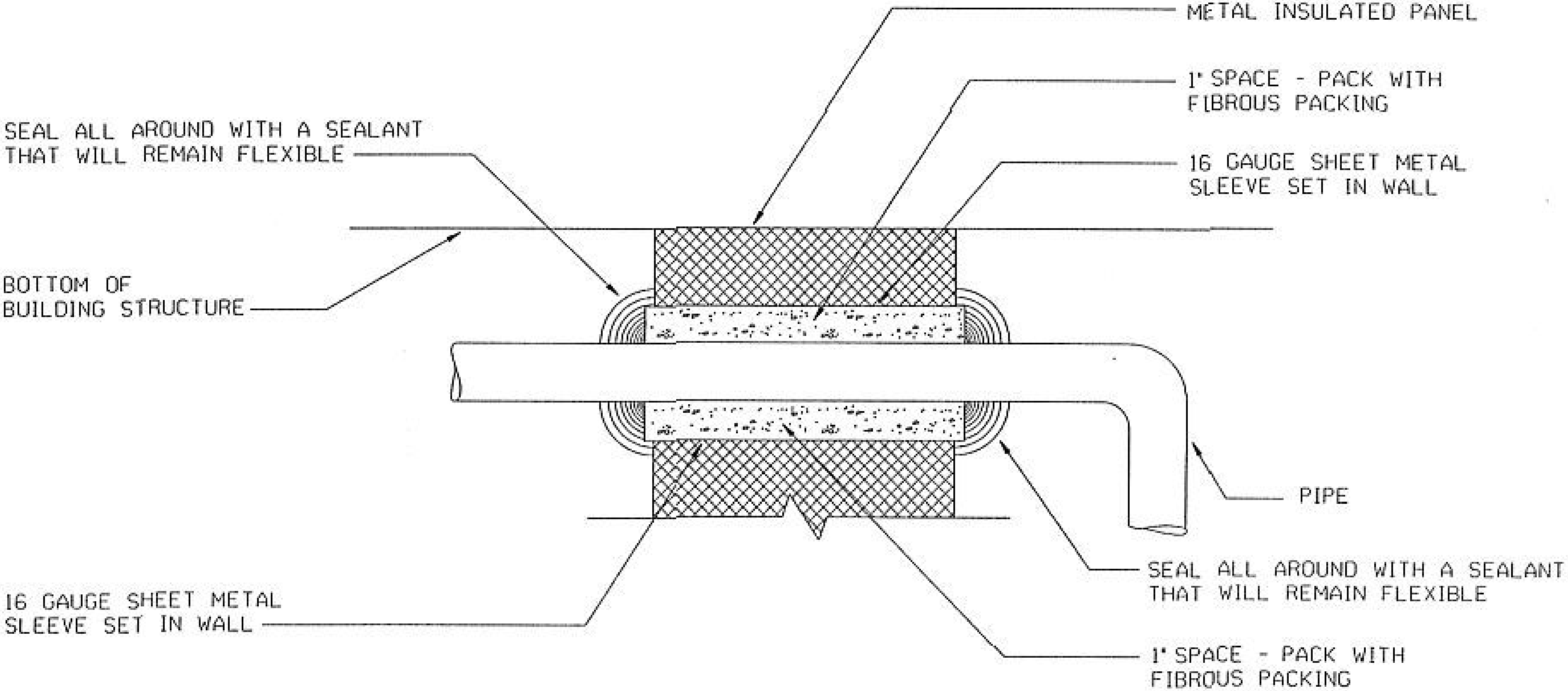
FBM
Design



FLEXIBLE DUCT SUPPORTS
N.T.S.

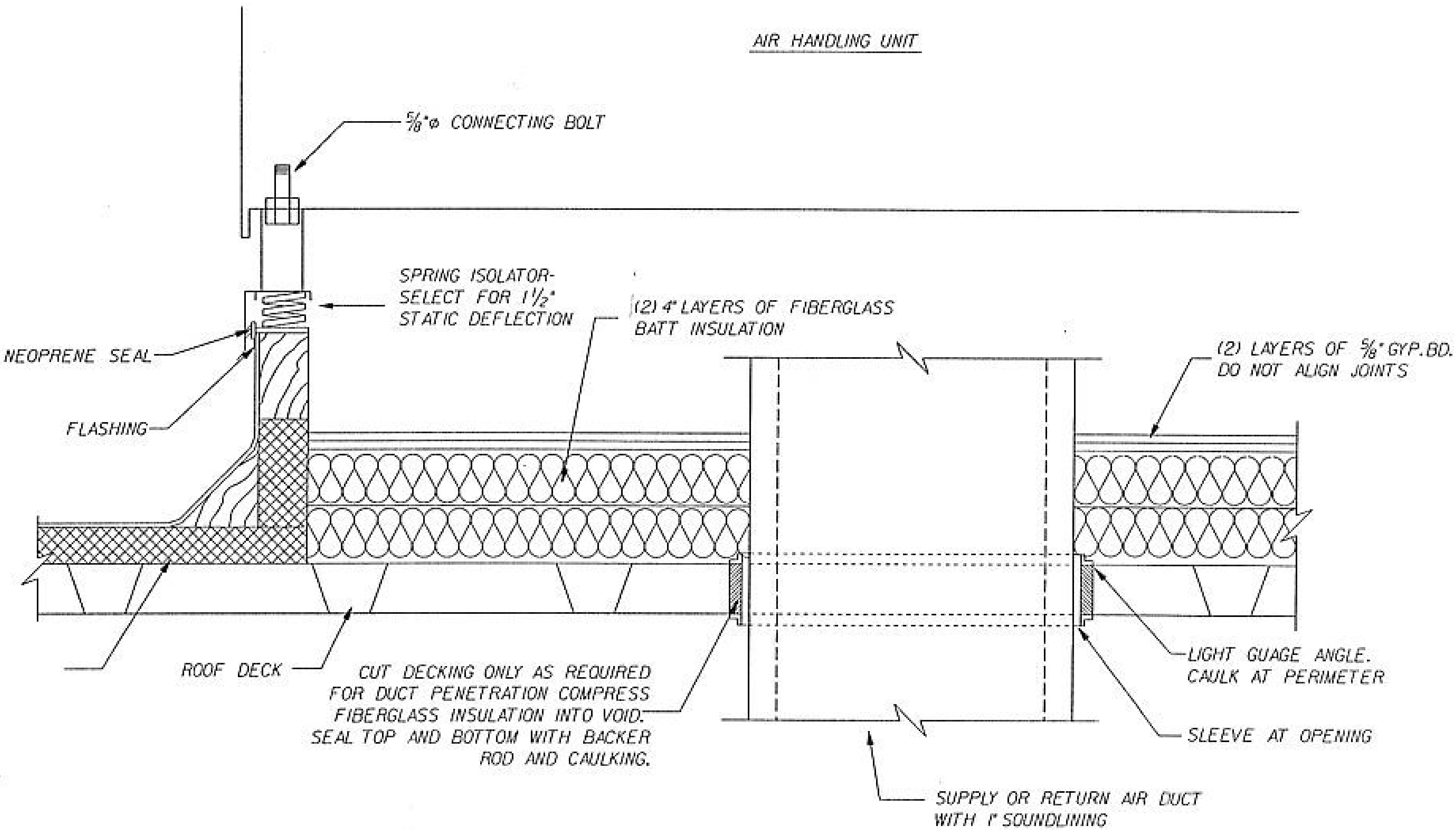


CEILING DIFFUSER DUCT CONNECTION
N.T.S.



DETAIL OF PIPE PASSING THRU WALLS

NO SCALE

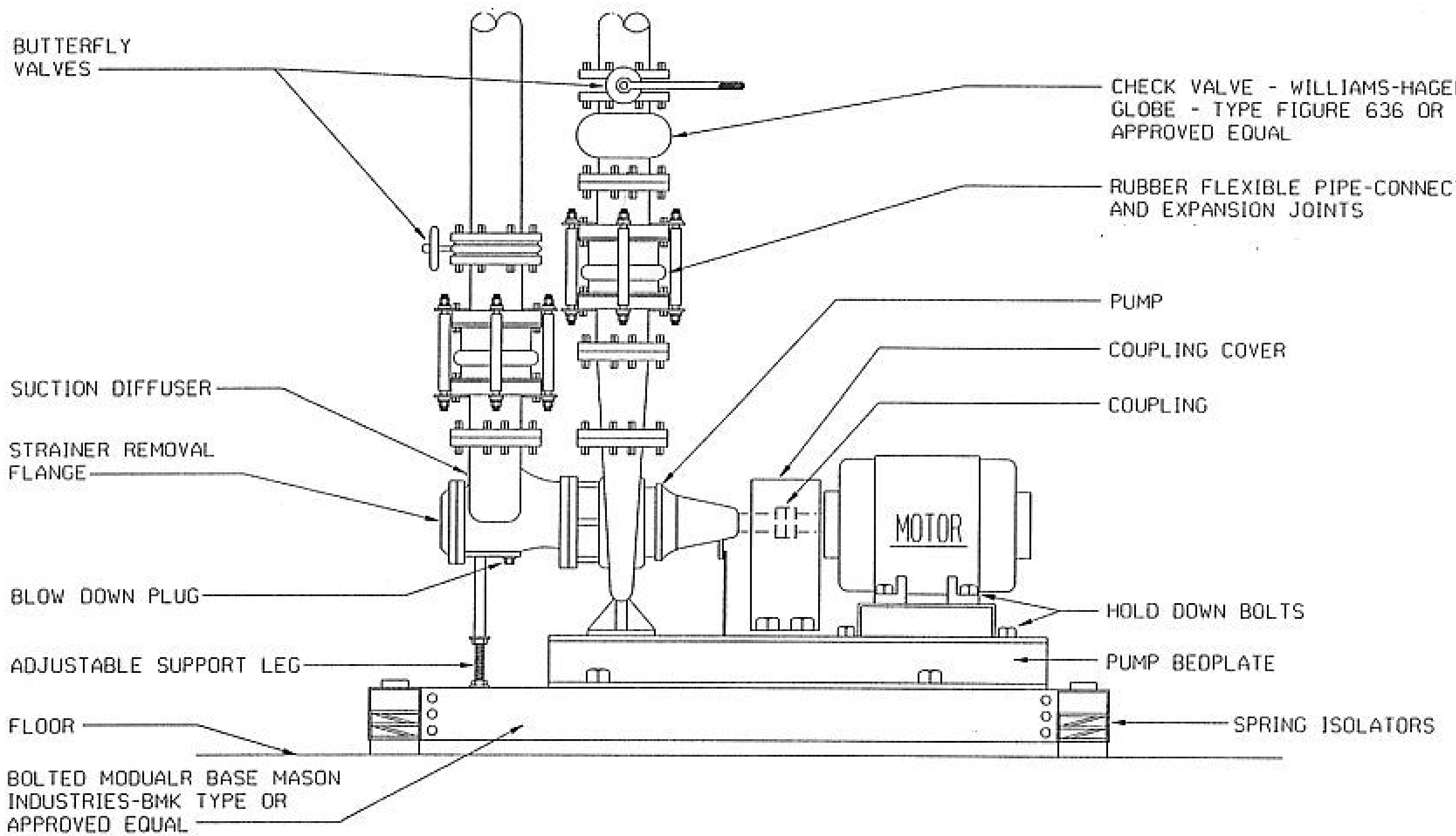


ROOFTOP UNIT CURB DETAIL

N.T.S.

d:\dgn\alpbase.dgn May. 10, 2001 18:41:11

NOTE:
SUPPORT PIPING SO NO WEIGHT RESTS ON PUMP CASING. USE SPRING HANGERS FROM PUMP CASING FOR FIRST 12 FT. OF PIPING



END SUCTION PUMP SIDE ELEVATION

NO SCALE

N. Case Studies (Articles)

Refer to subsequent pages.

Case Study

Daniel Boone High School, Washington County, Tennessee

Courtesy of Tennessee Valley Authority

Project

Daniel Boone High School, which serves over 1,100 students, recently underwent renovation for a new heating and cooling system, a GeoExchange System. Located in Washington County, Tennessee, the system serves the entire school including classrooms, kitchen, cafeteria, auditorium and a gym. Constructed in 1971, the original design utilized a two-pipe chilled water system for cooling and electric resistance heat for the 160,000 square foot school.

When renovation of the heating and cooling system was first discussed, the following design options were considered by the owner:

- Water loop heat pump (WLHP) with electric boiler
- WLHP with gas boiler
- WLHP with electric thermal storage
- 4 pipe system using a natural gas engine-driven chiller and boiler
- A WLHP with a closed loop GeoExchange system.

Energy savings from variable flow pumping were considered for all WLHP options.

Based on the analysis of the proposed systems, Washington County Schools chose the GeoExchange system with variable flow pumping for many reasons.

Energy Efficiency: Prior to the renovation, total energy costs for the school ranged from $181,000 to $240,000 per year. The GeoExchange system uses high efficiency water loop heat pumps which exceed ASHRAE Standard 90.1 requirements

The combination of high efficiency heat pumps with a geothermal heat exchanger provides a very efficient retrofit. Annual energy costs were projected to be $135,000, with annual energy use estimated at 2,232 mWh (kWh X 10^3).

Although the system renovation was scheduled for completion during the summer of 1995, a delay allowed for only two thirds of the heat exchanger to be installed before the 1995-96 winter heating season. The system operated through the very cold winter on a partial ground loop. The ground loop was completed in April 1996. Energy use for the 1996-97 school year (July - June), the first year of operation on the completed retrofit, was 2,298 mWh. **Figure 1** shows the relationship of energy usage to degree days for two years prior to retrofit, and two years after (including the one year with the partial heat exchanger).

Indoor Air Quality and Thermal Comfort: The original school design had provisions for adequate outside air but no significant indoor air quality issues were identified. The redesign incorporated the existing ventilation as it met ASHRAE standards. The GeoExchange system has the ability to provide simultaneous heating and cooling in any zone. The building is controlled using a direct digital control system, with individual zone setpoints ensuring a high level of thermal comfort.

Innovation: Daniel Boone High School is the first known school within the State of Tennessee to use a WHLP system incorporating a geothermal heat exchanger and variable flow pumping.

The geothermal heat exchanger consists of 320 boreholes, each 150 feet depth. Each borehole contains 300 feet of ¾ inch diameter polyethylene pipe. The boreholes are placed in sections of 20 holes at 15 foot centers, and 20 foot spacing between sections. Each section is valved to facilitate purging and to allow isolation in the unlikely event a leak should occur. The 8 inch system supply and return lines enter the school through the existing mechanical equipment room.

Parasitic pumping in WLHP and geothermal heat pump systems is an area with considerable potential for energy savings. Traditional designs incorporate constant operation of circulation pumps. This can substantially increase energy use, resulting in lower overall system efficiency. This system utilizes a pair of two-speed circulating pumps, each pump sized at approximately 80% of the system capacity (at full speed). The circulation pumps are staged as follows: Stage 1 -

one pump @ 1150 rpm; Stage 2 - one pump @ 1750 rpm; Stage 3 - two pumps @ 1750 rpm.

To ensure adequate system flow and optimum performance, the pumps are controlled by a combination of loop flow and system differential pressure using a programmable logic controller.

Each terminal heat pump unit uses a two-way valve to stop flow through the heat exchanger when heating or cooling is not required. (A small amount of bypass in the loop is maintained by eliminating the two-way valves on several small, strategically placed units.) As building load decreases, heat pumps cycle off. The flow rate is then reduced and the loop pumps ride up the pump curve. This increases the differential pressure until the controller reduces the pumping by one stage. As building load increases, the flow rate increases and differential pressure decreases. An additional pumping stage is then brought on. The system design provides variable flow pumping capability without the complexity and cost of variable speed drives. In all but peak conditions one pump on high speed will carry the building, providing acceptable system redundancy. The basic system schematic is illustrated in Figure 2.

Operation and Maintenance: The original system utilized a 300 ton CFC-11 chiller, and a cooling tower. Terminal unit ventilators with electric resistance heat served each zone. The new system contains high efficiency water loop heat pumps using HCFC-22. The chiller and cooling tower have been eliminated. Chemical treatment and make-up water requirements for the cooling tower have also been eliminated.

Should an individual heat pump require service, it would only impact a single zone rather than the whole building. The dual pumping arrangement provides an adequate level of redundancy in the event a pump requires servicing. Similarly, portions of the heat exchanger (sections of 20 boreholes) can be isolated from the system in the unlikely event that a leak (or other system damage) occurs, without major impact on system performance. Other considered systems would have included a boiler and a cooling tower, which have higher maintenance requirements than the GeoExchange system.

System Design: The system was designed anticipating the potential for changes in the use and occupancy of the school. Accordingly the ground loop was sized to allow additions and modifications. The school maintenance staff have converted a non-conditioned shop area in to a fitness center, and an abandoned indoor pool is being converted to a second gym area. The maintenance staff have been very impressed with the ability to simply tie additional heat pumps into the loop. The flexibility afforded by the design allows these type of modifications very easily. Another recent modification illustrating system flexibility was the addition of a water-to-water heat pump to handle the domestic hot water loads. This addition was completed in June, 1997 and supplements the existing 144 kW electric resistance water heater which provides back up water heating.

The system also provides flexibility for heating and cooling of individual zones when the school is unoccupied for vacations and holidays. Thus individual zones can be cooled without operating a central chiller plant as in the old system, or a boiler/cooling tower as in the base case retrofit system.

Cost Effectiveness: Water loop heat pumps were chosen as a base case for the retrofit conditions in order to provide simultaneous heating and cooling with a 2-pipe system. The traditional design approach would utilize a boiler and a cooling tower to control the loop temperature using a constant volume pumping system.

Energy costs for the base case were estimated at $164,000 per year. Analyses of the base case and alternate systems were accomplished using an hourly analysis model. The model was calibrated to actual energy use and weather data prior to the renovation. The energy costs for the installed system were estimated at $135,000 per year, for an energy savings of $29,000 per year over the base case.

A preliminary feasibility study estimated the maintenance cost for the GeoExchange system to be $0.05 per square foot per year less than the boiler/tower design. This $8,000 savings would include boiler, cooling tower, and heat exchanger maintenance as well as tower chemicals and makeup water usage. Total annual energy and maintenance savings were estimated at $37,000/yr. Using the actual energy costs of $139,000 for the 1996-97 school year, the annual savings would be $33,000 per year over the base case. Based on the energy costs for 1996-97 of $139,000 (with 4455 heating degree days) the system should be able to meet the original projection of $135,000 per year for a normal year (4143 degree days for Bristol, Tennessee area.) **Figure 3** shows the relationship of energy costs to degree days before and after retrofit. (Electric utility rates were constant for the period.)

The heat exchanger cost was $451,000 including a $100,000 change order to cover unexpected casing costs. Tennessee Valley Authority agreed to co-fund the as a research project in order to demonstrate and evaluate the GeoExchange system, particularly the variable flow pumping and the loop sizing. TVA provided $104,000 in direct funding plus the system monitoring costs. The costs for a conventional boiler, cooling tower, plate-frame heat exchanger, and associated pumping and controls were estimated at $150,000. The incremental cost to the school system was $197,000.

Using the estimated operations and maintenance savings of $8,000 and the actual 1996-97 energy costs savings (compared to a boiler/tower base case) a simple payback of 6 years is achieved. Using the projected costs for a normalized weather year reduces the payback to 5.3 years. The system is presently being monitored to validate its operation and maintenance costs. The detailed monitoring system was commissioned in May 1997.

The data is also being used to fine tune the system performance. It is anticipated that further optimization of the system operation (such as pump staging control points and strategy and building setback/ demand control) will reduce the annual energy consumption further, thus shortening the payback.

Note: This school like many others are moving to a year round usage. An example is the conversion of one shop area into a fitness center which is open all year. The effect of this increased usage will increase the relative energy use over previous years. However, from an overall energy impact this system responds very well to this type of use by allowing individual zones to be operated without operating a central plant. The heat exchanger at part load conditions will operate at cooler summer temperatures (or warmer winter temperatures) which will increase the heat pump efficiency and reduce utility costs.

Closing: This project offers an opportunity to demonstrate the marriage of two energy efficient technologies, variable flow pumping and geothermal heat pumps. This project was useful in introducing the closed loop ground heat exchanger and variable flow pumping concepts to regional well drillers and mechanical contractors. The school system is so pleased with the system that they have employed the technology in at least two other locations. It should also be pointed out that in a new construction application, a significant credit could be taken for a substantial reduction in mechanical equipment room requirements which would further reduce the system payback.

The school's system will be monitored to validate ground heat exchanger sizing programs and methods, and provide information on system pumping costs.

Facility

- 160,000 square foot
- 300 ton
- Closed loop geothermal heat exchanger
- 320 boreholes, each 150 feet depth
- Each borehole contains 300 feet of ¾ inch diameter polyethylene pipe.
- Boreholes are placed in sections of 20 holes at 15 foot centers, and 20 foot spacing between sections.

Location

The Daniel Boone High School is located in Washington County, Tennessee.

Contact Information

Case Study

Paint Lick Elementary School, Kentucky

Click on thumbnail for Full Size Photo.

Paint Lick Elementary School, Kentucky

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Background

Paint Lick Elementary School in Garrard County, Kentucky, was the first newly constructed school in Kentucky to be heated and cooled by geothermal heat pumps. According to Conn Abnee, Assistant Marketing Manager for East Kentucky Power Cooperative, a joint effort by the electric utilities and the heat pump manufacturer demonstrated geothermal to be the best choice for the new school.

State school board officials were skeptical about GHPs when the idea was initially proposed. "The theory is great, but we wanted proof that the equipment was adequate to meet the theory," said Michael Luscher, Director of the Division of Facilities Management. Because of the concerns of the local and state school board officials, advocates for the system went to great lengths to ensure that everyone would be satisfied. WaterFurnace International, Inc., the GHP manufacturer, even offered an unconditional guarantee on the system for two years.

"We look at each technology and each installation on an individual basis," said Mr. Luscher. "In this case, it appeared we were at a point when the technology had caught up with the theory. For that reason, we stepped into a pilot project with some assurances from the utilities and WaterFurnace."

The GHP system has become a learning tool for the Kentucky Department of Education and Paint Lick students. Completed in June of 1992, the highly efficient Paint Lick Elementary School project was envisioned as a pilot project for future school construction. The Department of Education's goal was to reduce energy consumption, operating costs, and system upkeep. "As educators, we try to encourage our children to make wise use of the environment, and I think this will be something that they [the students] will be able to look back on as adults," said Mary A. Davis, principal of Paint Lick Elementary School.

The architectural firm of Clotfelter-Samokar, specializing in educational facilities, welcomed the opportunity to become involved in the project. "We worked with geothermal in residential and commercial applications, but this was our first experience with geothermal in a school, and we were excited about its potential," said David Samokar, principal of the firm. Mr. Samokar has maintained his enthusiasm for geothermal heat pumps in schools, as evidenced by Clotfelter-Samokar's six subsequent designs of GHP schools.

Key Players

Facility
Paint Lick Elementary School
Garrard County
Lancaster, Kentucky

Ms. Mary A. Davis, Principal
Dr. William Wesley,
Superintendent
Garrard County School District
Phone: (606) 792-3018

Architect:
Clotfelter-Samokar, PCS
228 East Reynolds Road,
Suite 1
Lexington, Kentucky 40517
David Samokar, Principal
Phone: (606) 273-3700

Engineer:
Kaiser-Taulbee and Associates
190 Jefferson
Lexington, Kentucky 40508
Bob Kaiser
Phone: (606) 253-2459

Mechanical Contractor:
Green Mechanical Construction
2277 Danforth Drive
Lexington, Kentucky 40511
Glenn True, Vice President
Phone: (606) 252-4646

Electrical Contractor:
Cutter-Pulliam Electric Company
857 Contract Street
Lexington, Kentucky 40505
Bill Hosetler, President
Phone: (606) 252-7546

Manufacturer:
WaterFurnace International, Inc.
9000 Conservation Way
Fort Wayne, Indiana 46809
Phone: (219) 478-5667
Jim Smith, Commercial
Phone: (219) 478-5667

Loop Installer:
Ground Loop Systems of Kentucky
Tim Fencer

Electric Utilities:
Inter-County Rural Electric
Cooperative Corporation
Box 87
Danville, Kentucky 40423
Jim Jacobus, Vice President
Member Services and Marketing
Phone: (606) 792-4619

East Kentucky Power Cooperative
4758 Lexington Road
P.O. Box 707
Lexington, Kentucky 40392-0707
Conn Abnee, Assistant Marketing
Manager
Phone: (606) 744-4812
E-mail: conn@ekpc.com

System Description

Paint Lick Elementary School measures 39,564 square feet and is conditioned by 120 tons of WaterFurnace Premier AT Series geothermal heat pumps. The GHP system consists of six 1-ton units, two 2-ton units, nineteen 3-ton units, two 5-ton units, two 6.5-ton units, and four 7.5-ton units.

Underground heat transfer is provided by a vertical closed-loop pipe configuration constructed of PE3408 high-density polyethylene pipe. The loop field consists of five sets of 16 vertical loops, 163 feet deep, and four sets of 16 vertical loops, each 188 feet deep, cumulatively resulting in almost 10 miles of pipe buried behind the school, according to Tim Fencer of Ground Loop Systems of Kentucky.

The building loop is separated into multiple zones with separate pumps that operate only on demand in order to minimize pumping energy requirements.

Mr. Fencer, whose home also has a geothermal system, is confident about the school board's decision to go with geothermal technology. "It's the most efficient. It's the only way to go," said Fencer.

Costs

Total school construction cost was $2,339,111, which translates into a cost of $59.12 per square foot of school floorspace. The WaterFurnace geothermal system cost $380,000, or $9.60 per square foot, a very attractive figure for heating and air conditioning with individual temperature control in every room. Of the total GHP system cost, $272,887 ($6.90 per square foot) represents HVAC cost and $107,123 ($2.70 per square foot) went to the ground loop.

Savings

The reduction in energy consumption was projected to be 37% to 40%, a savings of 296,000 kWh at an electricity rate of 5¢/kWh. Other savings are achieved by avoiding a cooling tower and its costs for chemicals, maintenance, and general deterioration.

Financing, Rebates, and Guarantees

The school project was financed by the Kentucky Bond Authority through the Kentucky School Facilities Construction Commission with 20-year bonds. Inter-County Rural Electric Cooperative Corporation (IRECC) and its generation and transmission supplier, East Kentucky Power Cooperative (EKPC), shared the cost of a $125/ton rebate, which was a total incentive of $15,000. EKPC and WaterFurnace International, Inc. supplied technical assistance in the form of energy and cost savings estimates and attendance at two or three meetings to explain GHPs and their benefits to the school board.

"We always have an interest in our end-users, and that interest is that we want them to have a system with the lowest operating cost possible," said Leo Hill, IRECC. "And at this time, we know that there isn't a system that can do better than this one [geothermal]."

WaterFurnace demonstrated their faith in their product's performance and reliability by offering an unconditional guarantee on the GHP system for two years. If the Kentucky Department of Education was not satisfied with the geothermal system during that time, WaterFurnace would replace it with another heating and cooling system of the school board's choice. This guarantee was backed by a $100,000 bond to further illustrate the company's belief in geothermal technology. After four years of operation, the GHP system is still in place and running flawlessly.

Andy Taussig, who at that time headed the marketing department at WaterFurnace, explained that the company has complete confidence in its equipment and is interested in exploring opportunities for geothermal applications throughout the state. "We know that with geothermal, the Paint Lick School will save money, and those savings can be passed along to help benefit the teachers and the kids, which is really what's important here," Taussig said. "It just makes good economic sense. It's a win-win situation no matter how you look at it."

Another barrier WaterFurnace hoped to pull down was the lack of information available about geothermal. "By guaranteeing this system, we took the risk away from the school board and we believed once they saw what this system could do, awareness and acceptance of the technology will be our reward," Taussig explained. The strategy appears to have worked. Kentucky now has 15 schools with geothermal heat pump systems.

System Benefits

Having 35 separate heat pumps throughout the school allows each of the 20 classrooms, the library, cafeteria, offices, and the gym to have individual thermostats. The principal and teachers at Paint Lick Elementary could not be happier with the comfort and flexibility of the geothermal system. Dr. William Wesley, superintendent of the Garrard County School District, said the geothermal system provides a financial cost savings in terms of service, because alternative systems are more labor intensive and require continual custodial care.

In addition to the enhanced comfort levels and energy savings, the system has provided the school with several other benefits: the elimination of unsightly outdoor equipment such as cooling towers or rooftop units and a reduction in mechanical space requirements due to the elimination of boilers.

Award-Winning Design

The entire pilot project for Paint Lick Elementary School included other energy saving design characteristics, such as efficient lighting, and energy conserving architectural design and construction. These features, combined with the geo-thermal system, account for the school's attainment of an Engineering Excellence Award given by the National Society of Professional Engineers.

Lessons Learned/Subsequent Experience

Pilot projects are intended to teach lessons that will benefit future geothermal projects. The geothermal pilot project at the Paint Lick Elementary School has been no exception. When asked about any problems experienced with the Paint Lick GHP system, maintenance personnel could identify only one--the difficulty of changing filters. While this largely positive response points to the reliability of the system, it also suggests some design changes for future geothermal heat pump systems.

The horizontal GHP units at Paint Lick Elementary are hung from the 12-foot-high structural steel members, well above the 8-foot suspended ceilings. To minimize duct runs, the units were placed at the center of each classroom. To change filters, maintenance personnel must move students and desks to clear enough floorspace in the middle of the classroom to place a step ladder to remove suspended ceiling tiles. Then they must change ladders to climb the 12 feet to the GHP unit. Had Paint Lick's geothermal system been designed today, vertical GHP units would probably be designed with filter access from the hallway. Console units might be another choice.

After completion of the Paint Lick project, Kentucky instituted the Building Officials and Code Administrators (BOCA) code for ventilation air requirements that mandate 15-cubic-feet-per-minute of outside air for each building occupant. This ventilation requirement increases HVAC energy consumption, since much more outside air must be heated or cooled. However, David Samokar, architect for the Paint Lick project, is using some provisions in the code for new projects that reduce the energy penalties associated with the new ventilation requirements. These code provisions allow pre-conditioning spaces prior to occupancy without drawing outside air and using the time lag at the end of the day. In large spaces, Mr. Samokar has controlled the percentage of outside air drawn into the space with CO_2 sensors.

Conclusion

Although the children who attend Paint Lick Elementary School may not fully realize it now, they are learning and experiencing a valuable lesson in preserving the environment, and soon, other children will too. The school board has approved the use of geothermal in another new school, Camp Dick Robinson Elementary School, scheduled to be built this fall. I think there is no better [example] that a school board can set than to encourage students to protect the ecology of our region," Garrard County Superintendent Wesley said.

News of the benefits of using GHPs in schools is spreading across the country. Over 200 schools now use geothermal heating and cooling. Officials from the Bay District Schools in Panama City, Florida, recently visited the Paint Lick Elementary School to learn more about the cost savings and energy efficiency associated with the school's geothermal heating and cooling system. "Kentucky and its electric cooperatives are leaders in geothermal technology," said Claude Warren a commercial energy consultant with Gulf Power and the trip's organizer. "We decided that if we wanted to learn more about the benefits of geothermal, we might as well go right to the experts."

Another "center of GHP excellence" is located in Texas. The Austin Independent School District, considered by some to have started the GHP trend in schools, has built or retrofitted approximately 60 schools with geothermal heat pump systems.

Many northern schools are getting in the loop with geothermal as well. Based on the success of Minnesota's first school GHP system in Perham, Minnesota, many other schools in the area have been built or are being planned with geothermal systems. Approximately 40 schools in Minnesota are enjoying the benefits of geothermal systems. For example, the 140,000-square-foot West Central Area Secondary School in Barrett, Minnesota, uses 575 tons of Florida Heat Pump GHPs for space heating and cooling, domestic water heating, and ventilation air tempering.

Geothermal systems also have found their way into larger educational complexes, such as The Richard Stockton College of New Jersey. This GHP system is one of the largest in the country. The original renovation totaled about 1,400 tons of Trane GHP units, and approximately 200 tons of GHPs have been added recently.

As geothermal enters the classrooms of today's students, tomorrow's leaders may leave a little wiser about energy, ecology, and economy--a lesson to last a lifetime. *

Sources

Elementary school teaches lesson in efficiency, WaterFurnace Case Study #2, WaterFurnace International, Inc.

Jim Jacobus, Inter-County Rural Electric Cooperative Corporation, energy bills, July 1992 - August 1996.

Jim Jacobus, Inter-County Rural Electric Cooperative Corporation, draft write-up.

State approves new school for Paint Lick area, newspaper article, The Advocate-Messenger, Vicki Story Stevens, September 11, 1991.

Florida School Officials Get a Lesson in Geothermal, article, Power Partners (EKPC newsletter), East Kentucky Power Cooperative, Spring 1996.

David Samokar, Clotfelter-Samokar, phone conversation, October 1996.

Jim Jacobus, Inter-County Rural Electric Cooperative Corporation, phone conversation, October 1996.

Dr. William Wesley, Superintendent, Garrard County School District, phone

conversation, October 1996.

Bob Halvorson, HVAC Reps, Inc., Loretto, Minnesota, fact sheets and phone conversation, October 1996.

Expected Annual Savings

Evaporative Cooling Tower Fan Power	$750
Cooling Tower Make-Up Water	$250
Labor	$1,000
Chemicals (Cooling Tower Water Treatment)	$250
Geothermal System Winter Booster Energy (296,000 kWh at 5¢/kWh)	$14,000
Total	$16,250

* Information obtained from Kaiser-Taulbee and Associates Inc., the mechanical and electrical firm for the project

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Electricity Use Table

Electricity use, 1992-1996

	1992-1993 Electricity Use			1993-1994 Electricity Use			1994-1995 Electr	
Month	kWh Usage	kW Demand	Cost	kWh Usage	kW Demand	Cost	kWh Usage	kW Demand
------------	----------------	----------	---------	----------	---------	---------	---------	---------
August	27,120	93.6	$1,527	28,560	186.0	$1,608	29,880	163.2
September	33,840	199.2	$1,905	34,200	165.5	$1,925	31,920	158.4
October	33,360	192.0	$1,878	34,320	174.0	$1,932	33,000	195.6
November	34,320	216.0	$1,932	41,760	206.4	$2,351	37,920	199.2
December	51,960	234.0	$2,925	52,560	208.8	$2,959	39,720	219.6
January	50,640	246.0	$2,851	54,240	225.6	$3,053	58,440	254.4

February	42,840	242.4	$2,411	48,840	231.6	$2,749	55,080	241.2
March	54,240	219.6	$3,053	46,440	217.2	$2,614	36,840	230.4
April	34,200	196.8	$1,925	34,200	180.0	$1,925	33,840	196.8
May	29,880	164.4	$1,682	33,360	159.6	$1,878	29,520	169.2
June	20,760	134.4	$1,169	19,800	148.8	$1,115	22,320	105.6
July	23,520	104.4	$1,324	21,120	103.2	$1,189	21,960	114.0
12-Month Total	436,680	2,242.8	$24,581	449,400	2,206.8	$25,297	430,440	2,247.6
Monthly Average	36,390	186.9	$2,048	37,450	183.9	$2,108	35,870	187.3
Annual kWh/ft^2	11.04	.	.	11.36	.	.	10.88	.
Annual $/ft^2	$0.62	.	.	$0.64	.	.	$0.58	.

* 1995-1996 cost based on Inter-County RECC's All-Electric School rate of 5.88 c/kWh with no demand charge.

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HOMES / BUSINESSES / CASE STUDIES / CONSORTIUM / SEARCH / FEEDBACK / MEMBERS / LIST SERVER / BACK HOME

O. Load Calculations (Trace 700 Tables)

Refer to subsequent pages.

Room Che ksums
By BHKRA

Accounting

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 10			Mo/Hr: 7 / 10		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 73 / 51 / 35			OADB: 73		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	677	0		677	5.64	677	4.49	-1,416	-1,416	23.65
Glass Solar	6,600	0		6,600	55.01	6,600	43.81	0	0	0.00
Glass Cond	-89	0		-89	-0.74	-89	-0.59	-1,084	-1,084	18.09
Wall Cond	24	0		24	0.20	24	0.16	-203	-203	3.38
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-1,213			-1,213	-10.11	-232	-1.54	-2,743	-2,743	45.79
Sub Total ==>	5,999	0		5,999	50.00	6,979	46.33	-5,446	-5,446	90.91
Internal Loads										
Lights	4,096	0		4,096	34.14	4,096	27.19	0	0	0.00
People	4,500			4,500	37.51	2,500	16.60	0	0	0.00
Misc	2,457	0	0	2,457	20.48	2,457	16.31	0	0	0.00
Sub Total ==>	11,053	0	0	11,053	92.12	9,053	60.10	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-5,054	0	0	-5,054	-42.12	-968	-6.43	-544	-544	9.09
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	11,998	0	0	11,998	100.00	15,064	100.00	-5,990	-5,990	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.0
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	48	48
Supply	1,661	1,661
Mincfm	0	0
Return	1,909	1,909
Exhaust	248	248
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	12.0	12.0
cfm/sq ft	3.46	3.46
cfm/ton	1,407.31	
sq ft/ton	406.77	
Btu/hr-sq ft	29.50	-48.87
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	1.0	12.0	15.1	1,661	78.0	60.2	67.1	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.2	2.2	2.2	200	87.0	56.0	32.7	75.0	51.7	32.8
Totals	1.2	14.2								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	480		
Part	0		
ExFlr	0		
Roof	480	0	0
Wall	200	60	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-6.0	1,661	68.0	72.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-6.6	248	3.5	50.0
Opt Vent	-10.9	200	5.0	65.0
Total	-23.5			

Room Checksums

By BH[illegible]A

Administration Area

COOLING COIL PEAK						CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:		Mo/Hr: 7 / 10				Mo/Hr: 7 / 10		Mo/Hr: 13 / 1		
Outside Air:		OADB/WB/HR: 73 / 51 / 35				OADB: 73		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	2,910	0		2,910	5.56	2,910	4.63	-6,091	-6,091	24.31
Glass Solar	28,380	0		28,380	54.25	28,380	45.20	0	0	0.00
Glass Cond	-383	0		-383	-0.73	-383	-0.61	-4,659	-4,659	18.60
Wall Cond	102	0		102	0.20	102	0.16	-872	-872	3.48
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-5,215			-5,215	-9.97	-999	-1.59	-11,795	-11,795	47.09
Sub Total ==>	25,794	0		25,794	49.31	30,010	47.80	-23,417	-23,417	93.48
Internal Loads										
Lights	17,611	0		17,611	33.67	17,611	28.05	0	0	0.00
People	13,500			13,500	25.81	7,500	11.95	0	0	0.00
Misc	10,567	0	0	10,567	20.20	10,567	16.83	0	0	0.00
Sub Total ==>	41,678	0	0	41,678	79.67	35,678	56.83	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-15,161	0	0	-15,161	-28.98	-2,904	-4.63	-1,633	-1,633	6.52
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	52,311	0	0	52,311	100.00	62,784	100.00	-25,050	-25,050	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.0
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	600	600
Infil	206	206
Supply	6,921	6,921
Mincfm	0	0
Return	7,728	7,728
Exhaust	806	806
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	8.7	8.7
cfm/sq ft	3.35	3.35
cfm/ton	1,412.55	
sq ft/ton	421.24	
Btu/hr-sq ft	28.49	-38.33
No. People	30	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter DB/WB/HR F	Enter DB/WB/HR gr/lb	Leave DB/WB/HR F	Leave DB/WB/HR F	Leave DB/WB/HR gr/lb
Main Clg	4.4	52.3	62.8	6,921	78.0	60.3	67.6	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.5	6.5	6.5	600	87.0	56.0	32.7	75.0	51.7	32.8
Totals	4.9	58.8								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	2,064		
Part	0		
ExFlr	0		
Roof	2,064	0	0
Wall	860	258	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-25.1	6,921	68.0	72.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-21.4	806	3.5	50.0
Opt Vent	-32.7	600	5.0	65.0
Total	-79.1			

Project Name: School for St. Michaels
Dataset Name: C:\CDS\LOAD700\PROJECTS\SMASE.LDS

TRACE® Load 700 v2.3 calculated at 10:45 AM on 02/25/2001

Room Checksums
By BH..A

Adult Classroom No. 1

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 10					Mo/Hr: 7 / 10		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 73 / 51 / 35					OADB: 73		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	2,467	0		2,467	6.69	2,467	5.61	-5,164	-5,164	21.66
Glass Solar	19,380	0		19,380	52.53	19,380	44.03	0	0	0.00
Glass Cond	-557	0		-557	-1.51	-557	-1.26	-6,888	-6,888	28.89
Wall Cond	63	0		63	0.17	63	0.14	-861	-861	3.61
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-4,422			-4,422	-11.98	-847	-1.92	-10,001	-10,001	41.95
Sub Total ==>	16,932	0		16,932	45.89	20,507	46.59	-22,914	-22,914	96.12
Internal Loads										
Lights	14,932	0		14,932	40.47	14,932	33.92	0	0	0.00
People	7,650			7,650	20.73	4,250	9.66	0	0	0.00
Misc	5,973	0	0	5,973	16.19	5,973	13.57	0	0	0.00
Sub Total ==>	28,555	0	0	28,555	77.39	25,155	57.15	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,591	0	0	-8,591	-23.28	-1,646	-3.74	-925	-925	3.88
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	36,895	0	0	36,895	100.00	44,016	100.00	-23,840	-23,840	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	73.4
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	175	175
Supply	4,852	4,852
Mincfm	0	0
Return	5,367	5,367
Exhaust	515	515
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	7.0	7.0
cfm/sq ft	2.77	2.77
cfm/ton	1,435.18	
sq ft/ton	517.61	
Btu/hr-sq ft	23.18	-32.01
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	3.1	36.9	44.0	4,852	78.0	60.3	67.7	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	3.4	40.6								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	1,750		
Part	0		
ExFlr	0		
Roof	1,750	0	0
Wall	850	255	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-23.8	4,852	68.0	73.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-13.7	515	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-56.0			

Room Che[illegible]ksums
By BH[illegible]A

Adult Classroom No. 2

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 15					Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 87 / 56 / 33					OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	7,689	0		7,689	17.17	7,689	14.66	-5,164	-5,164	21.66
Glass Solar	18,105	0		18,105	40.43	18,105	34.51	0	0	0.00
Glass Cond	945	0		945	2.11	945	1.80	-6,888	-6,888	28.89
Wall Cond	59	0		59	0.13	59	0.11	-861	-861	3.61
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-2,344			-2,344	-5.23	1,429	2.72	-10,001	-10,001	41.95
Sub Total ==>	24,454	0		24,454	54.61	28,226	53.81	-22,914	-22,914	96.12
Internal Loads										
Lights	14,932	0		14,932	33.34	14,932	28.47	0	0	0.00
People	7,650			7,650	17.08	4,250	8.10	0	0	0.00
Misc	5,973	0	0	5,973	13.34	5,973	11.39	0	0	0.00
Sub Total ==>	28,555	0	0	28,555	63.76	25,155	47.95	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,227	0	0	-8,227	-18.37	-925	-1.76	-925	-925	3.88
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	44,781	0	0	44,781	100.00	52,456	100.00	-23,840	-23,840	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.5
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	175	175
Supply	5,783	5,783
Mincfm	0	0
Return	6,298	6,298
Exhaust	515	515
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	5.9	5.9
cfm/sq ft	3.30	3.30
cfm/ton	1,432.04	
sq ft/ton	433.37	
Btu/hr-sq ft	27.69	-32.01
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	3.7	44.8	52.5	5,783	78.0	60.3	68.0	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	4.0	48.5								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	1,750		
Part	0		
ExFlr	0		
Roof	1,750	0	0
Wall	850	255	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-23.8	5,783	68.0	72.5
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-13.7	515	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-56.0			

Room Checksums
By BH[illegible]A

Atrium No. 1

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time: / Outside Air:	Mo/Hr: 7 / 13	OADB/WB/HR: 84 / 55 / 34				Mo/Hr: 7 / 13	OADB: 84	Mo/Hr: 13 / 1	OADB: 5	
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	99,792	0		99,792	99.13	99,792	89.80	0	0	0.00
Skylite Cond	2,062	0		2,062	2.05	2,062	1.86	-21,355	-21,355	55.34
Roof Cond	1,878	0		1,878	1.87	1,878	1.69	-1,320	-1,320	3.42
Glass Solar	3,971	0		3,971	3.94	3,971	3.57	0	0	0.00
Glass Cond	492	0		492	0.49	492	0.44	-5,099	-5,099	13.21
Wall Cond	32	0		32	0.03	32	0.03	-303	-303	0.78
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-2,546			-2,546	-2.53	942	0.85	-9,601	-9,601	24.88
Sub Total ==>	105,682	0		105,682	104.98	109,170	98.24	-37,678	-37,678	97.63
Internal Loads										
Lights	2,867	0		2,867	2.85	2,867	2.58	0	0	0.00
People	0			0	0.00	0	0.00	0	0	0.00
Misc	0	0	0	0	0.00	0	0.00	0	0	0.00
Sub Total ==>	2,867	0	0	2,867	2.85	2,867	2.58	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-7,879	0	0	-7,879	-7.83	-914	-0.82	-914	-914	2.37
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	100,669	0	0	100,669	100.00	111,122	100.00	-38,592	-38,592	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	71.5
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	336	336
Infil	168	168
Supply	12,250	12,250
Mincfm	0	0
Return	12,754	12,754
Exhaust	504	504
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	2.7	2.7
cfm/sq ft	7.29	7.29
cfm/ton	1,409.37	
sq ft/ton	193.28	
Btu/hr-sq ft	62.08	-41.82
No. People	0	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	8.4	100.7	111.1	12,250	78.0	60.5	68.8	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.6	3.7	336	87.0	56.0	32.7	75.0	51.7	32.8
Totals	8.7	104.3								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	1,680		
Part	0		
ExFlr	0		
Roof	1,680	1,512	90
Wall	570	361	63

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-38.6	12,250	68.0	71.5
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-13.4	504	3.5	50.0
Opt Vent	-18.3	336	5.0	65.0
Total	-70.3			

Room Checksums

By BH[illegible]A

Atrium No. 2

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 13			Mo/Hr: 7 / 13		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 84 / 55 / 34			OADB: 84		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	28,690	0		28,690	103.76	28,690	93.59	0	0	0.00
Skylite Cond	593	0		593	2.14	593	1.93	-6,140	-6,140	64.34
Roof Cond	540	0		540	1.95	540	1.76	-380	-380	3.98
Glass Solar	0	0		0	0.00	0	0.00	0	0	0.00
Glass Cond	0	0		0	0.00	0	0.00	0	0	0.00
Wall Cond	0	0		0	0.00	0	0.00	0	0	0.00
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-732			-732	-2.65	271	0.88	-2,760	-2,760	28.93
Sub Total ==>	29,091	0		29,091	105.21	30,094	98.17	-9,280	-9,280	97.25
Internal Loads										
Lights	824	0		824	2.98	824	2.69	0	0	0.00
People	0			0	0.00	0	0.00	0	0	0.00
Misc	0	0	0	0	0.00	0	0.00	0	0	0.00
Sub Total ==>	824	0	0	824	2.98	824	2.69	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-2,265	0	0	-2,265	-8.19	-263	-0.86	-263	-263	2.75
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	27,650	0	0	27,650	100.00	30,655	100.00	-9,542	-9,542	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	71.1
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	97	97
Infil	48	48
Supply	3,379	3,379
Mincfm	0	0
Return	3,524	3,524
Exhaust	145	145
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	2.9	2.9
cfm/sq ft	7.00	7.00
cfm/ton	1,413.27	
sq ft/ton	201.99	
Btu/hr-sq ft	59.41	-38.61
No. People	0	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	2.3	27.7	30.7	3,379	78.0	60.5	68.7	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.1	1.0	1.1	97	87.0	56.0	32.7	75.0	51.7	32.8
Totals	2.4	28.7								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	483		
Part	0		
ExFlr	0		
Roof	483	435	90
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-9.5	3,379	68.0	71.1
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-3.9	145	3.5	50.0
Opt Vent	-5.3	97	5.0	65.0
Total	-18.6			

Room Ch[illegible]ksums

By BH[illegible]A

Cafeteria

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 8 / 15					Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 79 / 55 / 39					OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	16,941	0		16,941	15.29	19,332	14.61	-12,984	-12,984	22.30
Glass Solar	41,700	0		41,700	37.64	40,310	30.46	0	0	0.00
Glass Cond	234	0		234	0.21	1,751	1.32	-12,552	-12,552	21.56
Wall Cond	64	0		64	0.06	234	0.18	-2,106	-2,106	3.62
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-7,295			-7,295	-6.59	3,592	2.71	-25,145	-25,145	43.18
Sub Total ==>	51,643	0		51,643	46.62	65,219	49.29	-52,787	-52,787	90.65
Internal Loads										
Lights	37,543	0		37,543	33.89	37,543	28.37	0	0	0.00
People	55,000			55,000	49.65	27,500	20.78	0	0	0.00
Misc	7,509	0	0	7,509	6.78	7,509	5.67	0	0	0.00
Sub Total ==>	100,052	0	0	100,052	90.32	72,552	54.83	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-40,919	0	0	-40,919	-36.94	-5,443	-4.11	-5,443	-5,443	9.35
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	110,776	0	0	110,776	100.00	132,328	100.00	-58,230	-58,230	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.4
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	2,000	2,000
Infil	440	440
Supply	14,588	14,588
MinStop/Rh	0	0
Return	17,028	17,028
Exhaust	2,440	2,440
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	13.7	13.7
cfm/sq ft	3.32	3.32
cfm/ton	1,322.17	
sq ft/ton	398.80	
Btu/hr-sq ft	30.09	-52.69
No. People	100	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	9.2	110.8	126.5	14,588	78.0	60.2	67.3	68.0	57.5	69.8
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	1.8	21.6	21.8	2,000	87.0	56.0	32.7	75.0	51.7	32.8
Totals	11.0	132.4								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	4,400		
Part	0		
ExFlr	0		
Roof	4,400	0	0
Wall	2,150	695	32

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-58.2	14,588	68.0	72.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-64.8	2,440	3.5	50.0
Opt Vent	-108.9	2,000	5.0	65.0
Total	-231.9			

Room Checksums
By BH[illegible]A

Classroom No. 1

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 15			Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 87 / 56 / 33			OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	11,533	0		11,533	24.78	11,533	20.56	-7,746	-7,746	23.20
Glass Solar	6,525	0		6,525	14.02	6,525	11.63	0	0	0.00
Glass Cond	1,215	0		1,215	2.61	1,215	2.17	-8,951	-8,951	26.81
Wall Cond	-1	0		-1	0.00	-1	0.00	-760	-760	2.28
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-3,515			-3,515	-7.55	2,143	3.82	-15,001	-15,001	44.94
Sub Total ==>	15,756	0		15,756	33.86	21,415	38.18	-32,458	-32,458	97.23
Internal Loads										
Lights	22,398	0		22,398	48.13	22,398	39.93	0	0	0.00
People	7,650			7,650	16.44	4,250	7.58	0	0	0.00
Misc	8,959	0	0	8,959	19.25	8,959	15.97	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	83.82	35,607	63.47	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,227	0	0	-8,227	-17.68	-925	-1.65	-925	-925	2.77
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	46,536	0	0	46,536	100.00	56,097	100.00	-33,383	-33,383	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	74.0
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	6,184	6,184
Mincfm	0	0
Return	6,787	6,787
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	5.5	5.5
cfm/sq ft	2.36	2.36
cfm/ton	1,477.92	
sq ft/ton	627.34	
Btu/hr-sq ft	19.13	-25.86
No. People	17	

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-33.4	6,184	68.0	74.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-67.9			

COOLING COIL SELECTION

	Total Capacity tons	MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	F	gr/lb	Leave DB/WB/HR F	F	gr/lb
Main Clg	3.9	46.5	56.1	6,184	78.0	60.3	67.6	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	4.2	50.2								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	750	225	30

Room Checksums
By BH[illegible]A

Classroom No. 2

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 15			Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 87 / 56 / 33			OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	11,533	0		11,533	24.78	11,533	20.56	-7,746	-7,746	23.20
Glass Solar	6,525	0		6,525	14.02	6,525	11.63	0	0	0.00
Glass Cond	1,215	0		1,215	2.61	1,215	2.17	-8,951	-8,951	26.81
Wall Cond	-1	0		-1	0.00	-1	0.00	-760	-760	2.28
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-3,515			-3,515	-7.55	2,143	3.82	-15,001	-15,001	44.94
Sub Total ==>	15,756	0		15,756	33.86	21,415	38.18	-32,458	-32,458	97.23
Internal Loads										
Lights	22,398	0		22,398	48.13	22,398	39.93	0	0	0.00
People	7,650			7,650	16.44	4,250	7.58	0	0	0.00
Misc	8,959	0	0	8,959	19.25	8,959	15.97	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	83.82	35,607	63.47	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,227	0	0	-8,227	-17.68	-925	-1.65	-925	-925	2.77
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	46,536	0	0	46,536	100.00	56,097	100.00	-33,383	-33,383	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	74.0
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	6,184	6,184
Mincfm	0	0
Return	6,787	6,787
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	5.5	5.5
cfm/sq ft	2.36	2.36
cfm/ton	1,477.92	
sq ft/ton	627.34	
Btu/hr-sq ft	19.13	-25.86
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	F	gr/lb	Leave DB/WB/HR F	F	gr/lb
Main Clg	3.9	46.5	56.1	6,184	78.0	60.3	67.6	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	4.2	50.2								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	750	225	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-33.4	6,184	68.0	74.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-67.9			

Project Name: School for St. Michaels
Dataset Name: C:\CDS\LOAD700\PROJECTS\SMASE.LDS

TRACE® Load 700 v2.3 calculated at 10:45 AM on 02/25/2001

Room Checksums

By BH[illegible]A

Classroom No. 3

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 15			Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 87 / 56 / 33			OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	11,533	0		11,533	22.00	11,533	18.61	-7,746	-7,746	20.55
Glass Solar	11,880	0		11,880	22.66	11,880	19.17	0	0	0.00
Glass Cond	1,688	0		1,688	3.22	1,688	2.72	-12,394	-12,394	32.89
Wall Cond	62	0		62	0.12	62	0.10	-1,621	-1,621	4.30
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-3,515			-3,515	-6.71	2,143	3.46	-15,001	-15,001	39.80
Sub Total ==>	21,647	0		21,647	41.29	27,306	44.05	-36,763	-36,763	97.54
Internal Loads										
Lights	22,398	0		22,398	42.72	22,398	36.13	0	0	0.00
People	7,650			7,650	14.59	4,250	6.86	0	0	0.00
Misc	8,959	0	0	8,959	17.09	8,959	14.45	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	74.40	35,607	57.44	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,227	0	0	-8,227	-15.69	-925	-1.49	-925	-925	2.46
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	52,426	0	0	52,426	100.00	61,987	100.00	-37,688	-37,688	100.00

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	F	gr/lb	Leave DB/WB/HR F	F	gr/lb
Main Clg	4.4	52.4	62.0	6,833	78.0	60.3	67.8	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	4.7	56.1								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	1,450	330	23

TEMPERATURES

	Clg	Htg
SADB	68.0	74.1
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	6,833	6,833
Mincfm	0	0
Return	7,436	7,436
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	5.0	5.0
cfm/sq ft	2.60	2.60
cfm/ton	1,461.64	
sq ft/ton	561.47	
Btu/hr-sq ft	21.37	-27.50
No. People	17	

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-37.7	6,833	68.0	74.1
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-72.2			

Room Che[illegible]ksums
By BH[illegible]A

Classroom No. 4

COOLING COIL PEAK / CLG SPACE PEAK / HEATING COIL PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 9 / 14; Outside Air: OADB/WB/HR: 76 / 53 / 35
CLG Space Peak — Mo/Hr: 9 / 14; OADB: 76
Heating Coil Peak — Mo/Hr: 13 / 1; OADB: 5

	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	8,644	0		8,644	15.35	8,644	13.28	-7,746	-7,746	27.18
Glass Solar	22,275	0		22,275	39.56	22,275	34.21	0	0	0.00
Glass Cond	-107	0		-107	-0.19	-107	-0.16	-4,064	-4,064	14.26
Wall Cond	10	0		10	0.02	10	0.01	-760	-760	2.67
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-5,712			-5,712	-10.14	-397	-0.61	-15,001	-15,001	52.64
Sub Total ==>	25,109	0		25,109	44.59	30,424	46.73	-27,571	-27,571	96.75
Internal Loads										
Lights	22,398	0		22,398	39.78	22,398	34.40	0	0	0.00
People	7,650			7,650	13.59	4,250	6.53	0	0	0.00
Misc	8,959	0	0	8,959	15.91	8,959	13.76	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	69.27	35,607	54.69	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-7,806	0	0	-7,806	-13.86	-925	-1.42	-925	-925	3.25
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	56,310	0	0	56,310	100.00	65,106	100.00	-28,496	-28,496	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.4
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	7,177	7,177
Mincfm	0	0
Return	7,780	7,780
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	4.7	4.7
cfm/sq ft	2.73	2.73
cfm/ton	1,435.79	
sq ft/ton	525.13	
Btu/hr-sq ft	22.85	-24.00
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	4.7	56.3	65.1	7,177	78.0	60.4	68.1	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	5.0	60.0								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	750	225	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-28.5	7,177	68.0	72.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-63.0			

Room Checksums

By BHK[illegible]A

Classroom No. 5

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 10					Mo/Hr: 7 / 10		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 73 / 51 / 35					OADB: 73		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	3,701	0		3,701	7.12	3,701	6.08	-7,746	-7,746	27.18
Glass Solar	24,750	0		24,750	47.61	24,750	40.64	0	0	0.00
Glass Cond	-334	0		-334	-0.64	-334	-0.55	-4,064	-4,064	14.26
Wall Cond	89	0		89	0.17	89	0.15	-760	-760	2.67
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-6,633			-6,633	-12.76	-1,271	-2.09	-15,001	-15,001	52.64
Sub Total ==>	21,574	0		21,574	41.50	26,936	44.23	-27,571	-27,571	96.75
Internal Loads										
Lights	22,398	0		22,398	43.08	22,398	36.78	0	0	0.00
People	7,650			7,650	14.71	4,250	6.98	0	0	0.00
Misc	8,959	0	0	8,959	17.23	8,959	14.71	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	75.03	35,607	58.47	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,591	0	0	-8,591	-16.52	-1,646	-2.70	-925	-925	3.25
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	51,989	0	0	51,989	100.00	60,897	100.00	-28,496	-28,496	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.7
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	6,713	6,713
Mincfm	0	0
Return	7,316	7,316
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	5.1	5.1
cfm/sq ft	2.56	2.56
cfm/ton	1,447.21	
sq ft/ton	565.88	
Btu/hr-sq ft	21.21	-24.00
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	4.3	52.0	60.9	6,713	78.0	60.3	68.0	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	4.6	55.7								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	750	225	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-28.5	6,713	68.0	72.7
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-63.0			

Room Checksums
By BH[illegible]A

Classroom No. 6

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 15					Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 87 / 56 / 33					OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	11,533	0		11,533	18.62	11,533	16.13	-7,746	-7,746	27.18
Glass Solar	22,500	0		22,500	36.32	22,500	31.46	0	0	0.00
Glass Cond	567	0		567	0.92	567	0.79	-4,064	-4,064	14.26
Wall Cond	89	0		89	0.14	89	0.12	-760	-760	2.67
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-3,515			-3,515	-5.67	2,143	3.00	-15,001	-15,001	52.64
Sub Total ==>	31,174	0		31,174	50.32	36,833	51.50	-27,571	-27,571	96.75
Internal Loads										
Lights	22,398	0		22,398	36.15	22,398	31.32	0	0	0.00
People	7,650			7,650	12.35	4,250	5.94	0	0	0.00
Misc	8,959	0	0	8,959	14.46	8,959	12.53	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	62.96	35,607	49.79	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,227	0	0	-8,227	-13.28	-925	-1.29	-925	-925	3.25
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	61,953	0	0	61,953	100.00	71,514	100.00	-28,496	-28,496	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.0
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	7,884	7,884
Mincfm	0	0
Return	8,486	8,486
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	4.3	4.3
cfm/sq ft	3.00	3.00
cfm/ton	1,441.49	
sq ft/ton	479.97	
Btu/hr-sq ft	25.00	-24.00
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	5.2	62.0	71.5	7,884	78.0	60.4	68.2	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	5.5	65.6								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	750	225	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-28.5	7,884	68.0	72.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-63.0			

Room Checksums
By BHKRA

Classroom No. 7

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 10					Mo/Hr: 7 / 10		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 73 / 51 / 35					OADB: 73		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	3,701	0		3,701	7.12	3,701	6.08	-7,746	-7,746	27.18
Glass Solar	24,750	0		24,750	47.61	24,750	40.64	0	0	0.00
Glass Cond	-334	0		-334	-0.64	-334	-0.55	-4,064	-4,064	14.26
Wall Cond	89	0		89	0.17	89	0.15	-760	-760	2.67
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-6,633			-6,633	-12.76	-1,271	-2.09	-15,001	-15,001	52.64
Sub Total ==>	21,574	0		21,574	41.50	26,936	44.23	-27,571	-27,571	96.75
Internal Loads										
Lights	22,398	0		22,398	43.08	22,398	36.78	0	0	0.00
People	7,650			7,650	14.71	4,250	6.98	0	0	0.00
Misc	8,959	0	0	8,959	17.23	8,959	14.71	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	75.03	35,607	58.47	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,591	0	0	-8,591	-16.52	-1,646	-2.70	-925	-925	3.25
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	51,989	0	0	51,989	100.00	60,897	100.00	-28,496	-28,496	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.7
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	6,713	6,713
Mincfm	0	0
Return	7,316	7,316
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	5.1	5.1
cfm/sq ft	2.56	2.56
cfm/ton	1,447.21	
sq ft/ton	565.88	
Btu/hr-sq ft	21.21	-24.00
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	4.3	52.0	60.9	6,713	78.0	60.3	68.0	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	4.6	55.7								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	750	225	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-28.5	6,713	68.0	72.7
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-63.0			

Room Checksums
By BHKRA

Classroom No. 8

COOLING COIL PEAK / CLG SPACE PEAK / HEATING COIL PEAK

	Cooling Coil Peak		Clg Space Peak	Heating Coil Peak
Peaked at Time:	Mo/Hr: 7 / 15		Mo/Hr: 7 / 15	Mo/Hr: 13 / 1
Outside Air:	OADB/WB/HR: 87 / 56 / 33		OADB: 87	OADB: 5

	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	11,533	0		11,533	18.62	11,533	16.13	-7,746	-7,746	27.18
Glass Solar	22,500	0		22,500	36.32	22,500	31.46	0	0	0.00
Glass Cond	567	0		567	0.92	567	0.79	-4,064	-4,064	14.26
Wall Cond	89	0		89	0.14	89	0.12	-760	-760	2.67
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-3,515			-3,515	-5.67	2,143	3.00	-15,001	-15,001	52.64
Sub Total ==>	31,174	0		31,174	50.32	36,833	51.50	-27,571	-27,571	96.75
Internal Loads										
Lights	22,398	0		22,398	36.15	22,398	31.32	0	0	0.00
People	7,650			7,650	12.35	4,250	5.94	0	0	0.00
Misc	8,959	0	0	8,959	14.46	8,959	12.53	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	62.96	35,607	49.79	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,227	0	0	-8,227	-13.28	-925	-1.29	-925	-925	3.25
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	61,953	0	0	61,953	100.00	71,514	100.00	-28,496	-28,496	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.0
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	7,884	7,884
Mincfm	0	0
Return	8,486	8,486
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	4.3	4.3
cfm/sq ft	3.00	3.00
cfm/ton	1,441.49	
sq ft/ton	479.97	
Btu/hr-sq ft	25.00	-24.00
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	5.2	62.0	71.5	7,884	78.0	60.4	68.2	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	5.5	65.6								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	750	225	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-28.5	7,884	68.0	72.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-63.0			

Room Checksums

By BHKRA

Classroom No. 9

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 15			Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 87 / 56 / 33			OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	11,533	0		11,533	18.23	11,533	15.83	-7,746	-7,746	25.73
Glass Solar	23,660	0		23,660	37.39	23,660	32.48	0	0	0.00
Glass Cond	725	0		725	1.14	725	0.99	-5,216	-5,216	17.33
Wall Cond	100	0		100	0.16	100	0.14	-1,216	-1,216	4.04
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-3,515			-3,515	-5.56	2,143	2.94	-15,001	-15,001	49.83
Sub Total ==>	32,503	0		32,503	51.36	38,161	52.39	-29,180	-29,180	96.93
Internal Loads										
Lights	22,398	0		22,398	35.39	22,398	30.75	0	0	0.00
People	7,650			7,650	12.09	4,250	5.83	0	0	0.00
Misc	8,959	0	0	8,959	14.16	8,959	12.30	0	0	0.00
Sub Total ==>	39,007	0	0	39,007	61.64	35,607	48.88	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,227	0	0	-8,227	-13.00	-925	-1.27	-925	-925	3.07
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	63,282	0	0	63,282	100.00	72,843	100.00	-30,105	-30,105	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.1
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	340	340
Infil	263	263
Supply	8,030	8,030
Mincfm	0	0
Return	8,633	8,633
Exhaust	603	603
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	4.2	4.2
cfm/sq ft	3.06	3.06
cfm/ton	1,439.14	
sq ft/ton	470.45	
Btu/hr-sq ft	25.51	-24.61
No. People	17	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	5.3	63.3	72.8	8,030	78.0	60.4	68.2	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.3	3.7	3.7	340	87.0	56.0	32.7	75.0	51.7	32.8
Totals	5.6	67.0								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	2,625		
Part	0		
ExFlr	0		
Roof	2,625	0	0
Wall	1,100	260	24

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-30.1	8,030	68.0	72.1
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-16.0	603	3.5	50.0
Opt Vent	-18.5	340	5.0	65.0
Total	-64.6			

Room Ch~cksums

By BH..RA

Conference Room No. 3

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 8 / 15			Mo/Hr: 9 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 79 / 55 / 39			OADB: 77		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	2,233	0		2,233	11.47	1,910	7.86	-1,712	-1,712	19.54
Glass Solar	10,416	0		10,416	53.50	11,648	47.92	0	0	0.00
Glass Cond	38	0		38	0.19	-31	-0.13	-2,023	-2,023	23.10
Wall Cond	-1	0		-1	-0.01	-10	-0.04	-620	-620	7.08
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-962			-962	-4.94	-51	-0.21	-3,315	-3,315	37.85
Sub Total ==>	11,724	0		11,724	60.22	13,465	55.40	-7,668	-7,668	87.57
Internal Loads										
Lights	4,949	0		4,949	25.42	4,949	20.36	0	0	0.00
People	9,000			9,000	46.23	5,000	20.57	0	0	0.00
Misc	1,980	0	0	1,980	10.17	1,980	8.14	0	0	0.00
Sub Total ==>	15,928	0	0	15,928	81.81	11,928	49.08	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,184	0	0	-8,184	-42.04	-1,089	-4.48	-1,089	-1,089	12.43
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	19,469	0	0	19,469	100.00	24,305	100.00	-8,757	-8,757	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	71.6
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	400	400
Infil	58	58
Supply	2,679	2,679
Mincfm	0	0
Return	3,137	3,137
Exhaust	458	458
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	14.9	14.9
cfm/sq ft	4.62	4.62
cfm/ton	1,351.34	
sq ft/ton	292.52	
Btu/hr-sq ft	41.02	-73.60
No. People	20	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	1.6	19.5	23.6	2,679	78.0	60.1	66.7	68.0	57.4	69.8
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.4	4.3	4.3	400	87.0	56.0	32.7	75.0	51.7	32.8
Totals	2.0	23.8								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	580		
Part	0		
ExFlr	0		
Roof	580	0	0
Wall	540	112	21

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-8.8	2,679	68.0	71.6
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-12.2	458	3.5	50.0
Opt Vent	-21.8	400	5.0	65.0
Total	-42.7			

Room Checksums
By BHKRA

Gymnasium

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 14					Mo/Hr: 7 / 14		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 86 / 56 / 33					OADB: 86		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	25,350	0		25,350	15.95	25,350	19.34	-18,268	-18,268	11.20
Glass Solar	15,400	0		15,400	9.69	15,400	11.75	0	0	0.00
Glass Cond	2,728	0		2,728	1.72	2,728	2.08	-31,196	-31,196	19.12
Wall Cond	349	0		349	0.22	349	0.27	-7,558	-7,558	4.63
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-231			-231	-0.15	6,784	5.17	-70,755	-70,755	43.37
Sub Total ==>	43,596	0		43,596	27.43	50,610	38.61	-127,777	-127,777	78.32
Internal Loads										
Lights	51,195	0		51,195	32.22	51,195	39.05	0	0	0.00
People	54,000			54,000	33.98	19,050	14.53	0	0	0.00
Misc	10,239	0	0	10,239	6.44	10,239	7.81	0	0	0.00
Sub Total ==>	115,434	0	0	115,434	72.64	80,484	61.39	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	0	0	0	-115	-0.07	0	0.00	0	-35,378	21.68
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	159,030	0	0	158,915	100.00	131,094	100.00	-127,777	-163,154	100.00

TEMPERATURES

	Clg	Htg
SADB	55.0	94.4
Plenum	80.0	70.0
Return	80.0	70.0
Ret/OA	80.7	63.3
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	600	600
Infil	1,200	1,200
Supply	5,781	5,781
Mincfm	0	0
Return	6,981	6,981
Exhaust	1,800	1,800
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	10.4	10.4
cfm/sq ft	0.96	0.96
cfm/ton	436.51	
sq ft/ton	453.07	
Btu/hr-sq ft	26.49	-34.41
No. People	30	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	13.2	158.9	134.5	5,781	80.7	55.8	41.7	55.0	43.8	34.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	13.2	158.9								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	6,000		
Part	0		
ExFlr	0		
Roof	6,000	0	0
Wall	5,500	440	8

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-206.4	5,781	55.0	94.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-206.4			

Room Checksums

By Br...RA

Kitchen

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 8 / 15					Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 79 / 55 / 39					OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	2,830	0		2,830	14.89	3,229	13.04	-2,169	-2,169	19.11
Glass Solar	4,118	0		4,118	21.67	4,118	16.62	0	0	0.00
Glass Cond	37	0		37	0.20	278	1.12	-2,033	-2,033	17.92
Wall Cond	-121	0		-121	-0.64	94	0.38	-1,857	-1,857	16.36
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-1,219			-1,219	-6.41	600	2.42	-4,200	-4,200	37.02
Sub Total ==>	5,645	0		5,645	29.70	8,319	33.58	-10,259	-10,259	90.41
Internal Loads										
Lights	6,271	0		6,271	33.00	6,271	25.31	0	0	0.00
People	9,000			9,000	47.36	5,000	20.18	0	0	0.00
Misc	6,271	0	0	6,271	33.00	6,271	25.31	0	0	0.00
Sub Total ==>	21,543	0	0	21,543	113.36	17,543	70.81	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-8,184	0	0	-8,184	-43.06	-1,089	-4.39	-1,089	-1,089	9.59
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	19,004	0	0	19,004	100.00	24,774	100.00	-11,348	-11,348	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.6
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	400	400
Infil	74	74
Supply	2,731	2,731
Mincfm	0	0
Return	3,205	3,205
Exhaust	474	474
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	14.6	14.6
cfm/sq ft	3.72	3.72
cfm/ton	1,404.81	
sq ft/ton	378.08	
Btu/hr-sq ft	31.74	-62.16
No. People	20	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	1.6	19.0	23.4	2,731	78.0	60.0	66.3	68.0	57.5	70.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.4	4.3	4.3	400	87.0	56.0	32.7	75.0	51.7	32.8
Totals	1.9	23.3								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	735		
Part	0		
ExFlr	0		
Roof	735	0	0
Wall	1,350	68	5

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-11.4	2,731	68.0	72.6
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-12.6	474	3.5	50.0
Opt Vent	-21.8	400	5.0	65.0
Total	-45.7			

Room Checksums

By Br[illegible]RA

Locker rooms

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 15					Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 87 / 56 / 33					OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	3,160	0		3,160	13.02	3,160	17.56	-2,238	-2,238	5.44
Glass Solar	487	0		487	2.01	487	2.71	0	0	0.00
Glass Cond	71	0		71	0.29	71	0.39	-689	-689	1.68
Wall Cond	-10	0		-10	-0.04	-10	-0.06	-289	-289	0.70
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	37			37	0.15	467	2.59	-4,334	-4,334	10.54
Sub Total ==>	3,745	0		3,745	15.43	4,175	23.19	-7,550	-7,550	18.36
Internal Loads										
Lights	6,271	0		6,271	25.84	6,271	34.84	0	0	0.00
People	12,800			12,800	52.74	6,300	35.00	0	0	0.00
Misc	1,254	0	0	1,254	5.17	1,254	6.97	0	0	0.00
Sub Total ==>	20,326	0	0	20,326	83.75	13,826	76.81	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	0	0	0	200	0.82	0	0.00	0	-23,585	57.34
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	-9,995	-9,995	24.30
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	24,070	0	0	24,270	100.00	18,000	100.00	-17,545	-41,130	100.00

TEMPERATURES

	Clg	Htg
SADB	55.0	94.4
Plenum	80.0	70.0
Return	80.0	70.0
Ret/OA	83.5	37.2
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	400	400
Infil	74	74
Supply	794	794
Mincfm	0	0
Return	867	867
Exhaust	474	474
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	50.4	50.4
cfm/sq ft	1.08	1.08
cfm/ton	392.46	
sq ft/ton	363.41	
Btu/hr-sq ft	33.02	-55.96
No. People	20	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	2.0	24.3	20.5	794	83.5	55.9	37.6	55.0	42.4	29.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	2.0	24.3								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	735		
Part	0		
ExFlr	0		
Roof	735	0	0
Wall	210	17	8

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-28.4	794	55.0	94.4
Aux Htg	0.0	0	0.0	0.0
Preheat	-12.8	794	37.2	55.0
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-41.1			

Room Checksums

By B...RA

Macrame Room

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 15			Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 87 / 56 / 33			OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	5,154	0		5,154	23.94	5,154	19.56	-3,461	-3,461	25.53
Glass Solar	1,914	0		1,914	8.89	1,914	7.26	0	0	0.00
Glass Cond	356	0		356	1.66	356	1.35	-2,625	-2,625	19.37
Wall Cond	0	0		0	0.00	0	0.00	-223	-223	1.64
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-1,571			-1,571	-7.30	958	3.63	-6,704	-6,704	49.44
Sub Total ==>	5,853	0		5,853	27.19	8,381	31.81	-13,013	-13,013	95.99
Internal Loads										
Lights	10,009	0		10,009	46.49	10,009	37.98	0	0	0.00
People	4,500			4,500	20.90	2,500	9.49	0	0	0.00
Misc	6,005	0	0	6,005	27.90	6,005	22.79	0	0	0.00
Sub Total ==>	20,514	0	0	20,514	95.29	18,514	70.26	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-4,840	0	0	-4,840	-22.48	-544	-2.07	-544	-544	4.01
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	21,527	0	0	21,527	100.00	26,351	100.00	-13,558	-13,558	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	73.2
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	117	117
Supply	2,905	2,905
Mincfm	0	0
Return	3,222	3,222
Exhaust	317	317
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	6.9	6.9
cfm/sq ft	2.48	2.48
cfm/ton	1,471.51	
sq ft/ton	594.20	
Btu/hr-sq ft	20.20	-28.02
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	1.8	21.5	26.4	2,905	78.0	60.2	67.4	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.2	2.2	2.2	200	87.0	56.0	32.7	75.0	51.7	32.8
Totals	2.0	23.7								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	1,173		
Part	0		
ExFlr	0		
Roof	1,173	0	0
Wall	220	66	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-13.6	2,905	68.0	73.2
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-8.4	317	3.5	50.0
Opt Vent	-10.9	200	5.0	65.0
Total	-32.9			

Room Ch[illegible]ksums
By BH[illegible]RA

Nurse

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 15					Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 87 / 56 / 33					OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	5,536	0		5,536	23.54	5,536	19.41	-3,718	-3,718	21.24
Glass Solar	4,176	0		4,176	17.76	4,176	14.64	0	0	0.00
Glass Cond	778	0		778	3.31	778	2.73	-5,728	-5,728	32.73
Wall Cond	-1	0		-1	0.00	-1	0.00	-313	-313	1.79
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-1,687			-1,687	-7.18	1,029	3.61	-7,201	-7,201	41.14
Sub Total ==>	8,802	0		8,802	37.43	11,518	40.38	-16,960	-16,960	96.89
Internal Loads										
Lights	10,751	0		10,751	45.72	10,751	37.69	0	0	0.00
People	4,500			4,500	19.14	2,500	8.76	0	0	0.00
Misc	4,300	0	0	4,300	18.29	4,300	15.08	0	0	0.00
Sub Total ==>	19,551	0	0	19,551	83.15	17,551	61.53	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-4,840	0	0	-4,840	-20.58	-544	-1.91	-544	-544	3.11
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	23,513	0	0	23,513	100.00	28,525	100.00	-17,504	-17,504	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	74.1
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	126	126
Supply	3,145	3,145
Mincfm	0	0
Return	3,471	3,471
Exhaust	326	326
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	6.4	6.4
cfm/sq ft	2.50	2.50
cfm/ton	1,469.68	
sq ft/ton	588.89	
Btu/hr-sq ft	20.38	-29.40
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	2.0	23.5	28.5	3,145	78.0	60.3	67.5	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.2	2.2	2.2	200	87.0	56.0	32.7	75.0	51.7	32.8
Totals	2.1	25.7								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	1,260		
Part	0		
ExFlr	0		
Roof	1,260	0	0
Wall	360	144	40

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-17.5	3,145	68.0	74.1
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-8.7	326	3.5	50.0
Opt Vent	-10.9	200	5.0	65.0
Total	-37.0			

Room Checksums

By B[illegible]RA

PT/OT No. 1

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 15			Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 87 / 56 / 33			OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	8,611	0		8,611	28.59	8,611	22.12	-5,784	-5,784	29.78
Glass Solar	1,197	0		1,197	3.97	1,197	3.07	0	0	0.00
Glass Cond	159	0		159	0.53	159	0.41	-1,138	-1,138	5.86
Wall Cond	42	0		42	0.14	42	0.11	-213	-213	1.10
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-2,625			-2,625	-8.72	1,600	4.11	-11,201	-11,201	57.67
Sub Total ==>	7,384	0		7,384	24.52	11,609	29.82	-18,335	-18,335	94.40
Internal Loads										
Lights	16,724	0		16,724	55.53	16,724	42.95	0	0	0.00
People	9,000			9,000	29.88	5,000	12.84	0	0	0.00
Misc	6,689	0	0	6,689	22.21	6,689	17.18	0	0	0.00
Sub Total ==>	32,413	0	0	32,413	107.62	28,413	72.98	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-9,679	0	0	-9,679	-32.14	-1,089	-2.80	-1,089	-1,089	5.60
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	30,118	0	0	30,118	100.00	38,934	100.00	-19,424	-19,424	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	73.0
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	400	400
Infil	196	196
Supply	4,292	4,292
Mincfm	0	0
Return	4,888	4,888
Exhaust	596	596
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	9.3	9.3
cfm/sq ft	2.19	2.19
cfm/ton	1,495.38	
sq ft/ton	682.88	
Btu/hr-sq ft	17.57	-29.09
No. People	20	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	2.5	30.1	38.9	4,292	78.0	60.1	66.7	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.4	4.3	4.3	400	87.0	56.0	32.7	75.0	51.7	32.8
Totals	2.9	34.4								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	1,960		
Part	0		
ExFlr	0		
Roof	1,960	0	0
Wall	210	63	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-19.4	4,292	68.0	73.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-15.8	596	3.5	50.0
Opt Vent	-21.8	400	5.0	65.0
Total	-57.0			

Room Ch[illegible]cksums

By Br[illegible]RA

PT/OT No. 2

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 7 / 15			Mo/Hr: 7 / 15		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 87 / 56 / 33			OADB: 87		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	8,611	0		8,611	24.46	8,611	19.56	-5,784	-5,784	29.78
Glass Solar	6,300	0		6,300	17.90	6,300	14.31	0	0	0.00
Glass Cond	159	0		159	0.45	159	0.36	-1,138	-1,138	5.86
Wall Cond	25	0		25	0.07	25	0.06	-213	-213	1.10
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-2,625			-2,625	-7.46	1,600	3.64	-11,201	-11,201	57.67
Sub Total ==>	12,470	0		12,470	35.42	16,695	37.93	-18,335	-18,335	94.40
Internal Loads										
Lights	16,724	0		16,724	47.50	16,724	37.99	0	0	0.00
People	9,000			9,000	25.57	5,000	11.36	0	0	0.00
Misc	6,689	0	0	6,689	19.00	6,689	15.20	0	0	0.00
Sub Total ==>	32,413	0	0	32,413	92.07	28,413	64.55	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-9,679	0	0	-9,679	-27.50	-1,089	-2.47	-1,089	-1,089	5.60
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	35,204	0	0	35,204	100.00	44,020	100.00	-19,424	-19,424	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.4
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	400	400
Infil	196	196
Supply	4,853	4,853
Mincfm	0	0
Return	5,449	5,449
Exhaust	596	596
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	8.2	8.2
cfm/sq ft	2.48	2.48
cfm/ton	1,473.18	
sq ft/ton	595.01	
Btu/hr-sq ft	20.17	-29.09
No. People	20	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	2.9	35.2	44.0	4,853	78.0	60.2	67.1	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.4	4.3	4.3	400	87.0	56.0	32.7	75.0	51.7	32.8
Totals	3.3	39.5								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	1,960		
Part	0		
ExFlr	0		
Roof	1,960	0	0
Wall	210	63	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-19.4	4,853	68.0	72.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-15.8	596	3.5	50.0
Opt Vent	-21.8	400	5.0	65.0
Total	-57.0			

Room Checksums

By B[illegible]RA

Pottery Room

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 9 / 11					Mo/Hr: 9 / 11		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 68 / 49 / 35					OADB: 68		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	1,579	0		1,579	4.24	1,579	3.80	-3,199	-3,199	16.68
Glass Solar	17,947	0		17,947	48.15	17,947	43.19	0	0	0.00
Glass Cond	-658	0		-658	-1.77	-658	-1.58	-4,397	-4,397	22.93
Wall Cond	4,492	0		4,492	12.05	4,492	10.81	-4,846	-4,846	25.26
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-3,194			-3,194	-8.57	-985	-2.37	-6,195	-6,195	32.30
Sub Total ==>	20,165	0		20,165	54.11	22,374	53.84	-18,637	-18,637	97.16
Internal Loads										
Lights	9,249	0		9,249	24.82	9,249	22.26	0	0	0.00
People	4,500			4,500	12.07	2,500	6.02	0	0	0.00
Misc	9,249	0	0	9,249	24.82	9,249	22.26	0	0	0.00
Sub Total ==>	22,998	0	0	22,998	61.71	20,998	50.53	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-5,893	0	0	-5,893	-15.81	-1,818	-4.37	-544	-544	2.84
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	37,270	0	0	37,270	100.00	41,555	100.00	-19,181	-19,181	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.6
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	108	108
Supply	4,581	4,581
Mincfm	0	0
Return	4,889	4,889
Exhaust	308	308
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	4.4	4.4
cfm/sq ft	4.23	4.23
cfm/ton	1,394.07	
sq ft/ton	329.88	
Btu/hr-sq ft	36.38	-35.29
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter DB/WB/HR F	Enter DB/WB/HR gr/lb	Leave DB/WB/HR F	Leave DB/WB/HR F	Leave DB/WB/HR gr/lb
Main Clg	3.1	37.3	41.6	4,581	78.0	60.5	68.6	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.2	2.2	2.2	200	87.0	56.0	32.7	75.0	51.7	32.8
Totals	3.3	39.4								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	1,084		
Part	0		
ExFlr	0		
Roof	1,084	0	0
Wall	525	137	26

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-19.2	4,581	68.0	72.6
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-8.2	308	3.5	50.0
Opt Vent	-10.9	200	5.0	65.0
Total	-38.3			

Room Checksums

By B...RA

Residential Office

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 9 / 14					Mo/Hr: 10 / 14		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 76 / 53 / 35					OADB: 74		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	1,054	0		1,054	11.25	766	6.23	-944	-944	21.73
Glass Solar	4,752	0		4,752	50.74	5,376	43.70	0	0	0.00
Glass Cond	-23	0		-23	-0.24	-51	-0.42	-867	-867	19.95
Wall Cond	2	0		2	0.02	-3	-0.02	-162	-162	3.73
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-696			-696	-7.44	-110	-0.90	-1,829	-1,829	42.08
Sub Total ==>	5,089	0		5,089	54.33	5,978	48.59	-3,802	-3,802	87.48
Internal Loads										
Lights	2,730	0		2,730	29.15	2,730	22.19	0	0	0.00
People	4,500			4,500	48.05	2,500	20.32	0	0	0.00
Misc	1,638	0	0	1,638	17.49	1,638	13.32	0	0	0.00
Sub Total ==>	8,869	0	0	8,869	94.70	6,869	55.83	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-4,592	0	0	-4,592	-49.03	-544	-4.42	-544	-544	12.52
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	9,365	0	0	9,365	100.00	12,302	100.00	-4,346	-4,346	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	71.6
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	32	32
Supply	1,340	1,340
Mincfm	0	0
Return	1,572	1,572
Exhaust	232	232
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	14.9	14.9
cfm/sq ft	4.19	4.19
cfm/ton	1,395.11	
sq ft/ton	333.12	
Btu/hr-sq ft	36.02	-66.84
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	0.8	9.4	12.1	1,340	78.0	60.1	66.6	68.0	57.5	70.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.2	2.2	2.2	200	87.0	56.0	32.7	75.0	51.7	32.8
Totals	1.0	11.5								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	320		
Part	0		
ExFlr	0		
Roof	320	0	0
Wall	160	48	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-4.3	1,340	68.0	71.6
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-6.2	232	3.5	50.0
Opt Vent	-10.9	200	5.0	65.0
Total	-21.4			

Room Ch?cksums
By B?..RA

Social

COOLING COIL PEAK / CLG SPACE PEAK / HEATING COIL PEAK

	Cooling Coil Peak		CLG Space Peak	Heating Coil Peak
Peaked at Time:	Mo/Hr: 8 / 15		Mo/Hr: 7 / 15	Mo/Hr: 13 / 1
Outside Air:	OADB/WB/HR: 79 / 55 / 39		OADB: 87	OADB: 5

	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	2,310	0		2,310	13.20	2,636	12.75	-1,771	-1,771	24.30
Glass Solar	7,560	0		7,560	43.20	7,200	34.81	0	0	0.00
Glass Cond	24	0		24	0.14	181	0.88	-1,300	-1,300	17.84
Wall Cond	3	0		3	0.02	29	0.14	-243	-243	3.34
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-995			-995	-5.68	490	2.37	-3,429	-3,429	47.05
Sub Total ==>	8,902	0		8,902	50.87	10,536	50.94	-6,743	-6,743	92.53
Internal Loads										
Lights	5,120	0		5,120	29.25	5,120	24.75	0	0	0.00
People	4,500			4,500	25.71	2,500	12.09	0	0	0.00
Misc	3,072	0	0	3,072	17.55	3,072	14.85	0	0	0.00
Sub Total ==>	12,691	0	0	12,691	72.51	10,691	51.69	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-4,092	0	0	-4,092	-23.38	-544	-2.63	-544	-544	7.47
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	17,502	0	0	17,502	100.00	20,683	100.00	-7,287	-7,287	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	71.5
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	60	60
Supply	2,280	2,280
Mincfm	0	0
Return	2,540	2,540
Exhaust	260	260
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	8.8	8.8
cfm/sq ft	3.80	3.80
cfm/ton	1,391.43	
sq ft/ton	366.15	
Btu/hr-sq ft	32.77	-41.79
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	1.5	17.5	20.1	2,280	78.0	60.3	67.5	68.0	57.5	69.9
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.2	2.2	2.2	200	87.0	56.0	32.7	75.0	51.7	32.8
Totals	1.6	19.7								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	600		
Part	0		
ExFlr	0		
Roof	600	0	0
Wall	240	72	30

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-7.3	2,280	68.0	71.5
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-6.9	260	3.5	50.0
Opt Vent	-10.9	200	5.0	65.0
Total	-25.1			

Room Checksums

By [illegible]RA

Staff Lounge

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 8 / 14			Mo/Hr: 9 / 14		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 79 / 55 / 40			OADB: 76		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	3,808	0		3,808	20.18	3,293	14.51	-2,951	-2,951	28.23
Glass Solar	2,640	0		2,640	13.99	3,960	17.45	0	0	0.00
Glass Cond	6	0		6	0.03	-19	-0.08	-722	-722	6.91
Wall Cond	-12	0		-12	-0.06	7	0.03	-521	-521	4.99
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-1,687			-1,687	-8.94	-151	-0.67	-5,715	-5,715	54.67
Sub Total ==>	4,755	0		4,755	25.19	7,089	31.23	-9,909	-9,909	94.79
Internal Loads										
Lights	8,533	0		8,533	45.21	8,533	37.59	0	0	0.00
People	4,500			4,500	23.84	2,500	11.01	0	0	0.00
Misc	5,120	0	0	5,120	27.12	5,120	22.56	0	0	0.00
Sub Total ==>	18,152	0	0	18,152	96.17	16,152	71.16	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-4,032	0	0	-4,032	-21.36	-544	-2.40	-544	-544	5.21
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	18,875	0	0	18,875	100.00	22,697	100.00	-10,454	-10,454	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.6
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	100	100
Supply	2,502	2,502
Mincfm	0	0
Return	2,802	2,802
Exhaust	300	300
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	8.0	8.0
cfm/sq ft	2.50	2.50
cfm/ton	1,427.26	
sq ft/ton	570.43	
Btu/hr-sq ft	21.04	-29.30
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB/WB/HR F	Enter F	Enter gr/lb	Leave DB/WB/HR F	Leave F	Leave gr/lb
Main Clg	1.6	18.9	22.1	2,502	78.0	60.2	67.4	68.0	57.5	70.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.2	2.2	2.2	200	87.0	56.0	32.7	75.0	51.7	32.8
Totals	1.8	21.0								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	1,000		
Part	0		
ExFlr	0		
Roof	1,000	0	0
Wall	400	40	10

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-10.5	2,502	68.0	72.6
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-8.0	300	3.5	50.0
Opt Vent	-10.9	200	5.0	65.0
Total	-29.3			

Room Ch[illegible]ksums
By BH[illegible]RA

Therapy Pools

COOLING COIL PEAK / CLG SPACE PEAK / HEATING COIL PEAK

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:	Mo/Hr: 7 / 15					Mo/Hr: 7 / 14		Mo/Hr: 13 / 1		
Outside Air:	OADB/WB/HR: 87 / 56 / 33					OADB: 86		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	8,428	0		8,428	23.38	8,281	24.46	-5,967	-5,967	13.32
Glass Solar	896	0		896	2.49	1,204	3.56	0	0	0.00
Glass Cond	55	0		55	0.15	49	0.14	-521	-521	1.16
Wall Cond	-5	0		-5	-0.01	-11	-0.03	-795	-795	1.77
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	98			98	0.27	1,108	3.27	-11,557	-11,557	25.80
Sub Total ==>	9,472	0		9,472	26.28	10,631	31.41	-18,840	-18,840	42.07
Internal Loads										
Lights	16,724	0		16,724	46.40	16,724	49.41	0	0	0.00
People	6,400			6,400	17.76	3,150	9.31	0	0	0.00
Misc	3,345	0	0	3,345	9.28	3,345	9.88	0	0	0.00
Sub Total ==>	26,468	0	0	26,468	73.44	23,218	68.59	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	0	0	0	100	0.28	0	0.00	0	-11,793	26.33
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	-14,152	-14,152	31.60
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	35,940	0	0	36,040	100.00	33,849	100.00	-32,992	-44,785	100.00

TEMPERATURES

	Clg	Htg
SADB	55.0	94.4
Plenum	80.0	70.0
Return	80.0	70.0
Ret/OA	80.9	61.3
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	200	200
Infil	196	196
Supply	1,493	1,493
Mincfm	0	0
Return	1,689	1,689
Exhaust	396	396
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	13.4	13.4
cfm/sq ft	0.76	0.76
cfm/ton	496.98	
sq ft/ton	652.61	
Btu/hr-sq ft	18.39	-27.19
No. People	10	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	3.0	36.0	35.1	1,493	80.9	55.8	41.4	55.0	45.4	40.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	3.0	36.0								

AREAS

	Gross Total	Glass sq ft	(%)
Floor	1,960		
Part	0		
ExFlr	0		
Roof	1,960	0	0
Wall	560	28	5

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-53.3	1,493	55.0	94.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-53.3			

Room Checksums
By BH[illegible]RA

Transportation Office

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time:			Mo/Hr: 8 / 10			Mo/Hr: 7 / 10		Mo/Hr: 13 / 1		
Outside Air:			OADB/WB/HR: 67 / 51 / 42			OADB: 73		OADB: 5		
	Space Sens. + Lat. Btuh	Ret. Air Sensible Btuh	Ret. Air Latent Btuh	Net Total Btuh	Percent Of Total (%)	Space Sensible Btuh	Percent Of Total (%)	Space Peak Space Sens Btuh	Coil Peak Tot Sens Btuh	Percent Of Total (%)
Envelope Loads										
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	262	0		262	3.05	395	4.13	-826	-826	18.88
Glass Solar	5,829	0		5,829	67.80	5,293	55.41	0	0	0.00
Glass Cond	-208	0		-208	-2.42	-99	-1.04	-1,210	-1,210	27.65
Wall Cond	3	0		3	0.03	30	0.32	-468	-468	10.69
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	-735			-735	-8.55	-136	-1.42	-1,600	-1,600	36.56
Sub Total ==>	5,151	0		5,151	59.91	5,483	57.40	-4,104	-4,104	93.78
Internal Loads										
Lights	2,389	0		2,389	27.79	2,389	25.01	0	0	0.00
People	2,250			2,250	26.17	1,250	13.09	0	0	0.00
Misc	1,433	0	0	1,433	16.67	1,433	15.01	0	0	0.00
Sub Total ==>	6,073	0	0	6,073	70.64	5,073	53.10	0	0	0.00
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	-2,626	0	0	-2,626	-30.55	-1,004	-10.51	-272	-272	6.22
Sup. Fan Heat				0	0.00		0.00		0	0.00
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total ==>	8,597	0	0	8,597	100.00	9,552	100.00	-4,376	-4,376	100.00

TEMPERATURES

	Clg	Htg
SADB	68.0	72.3
Plenum	78.0	68.0
Return	78.0	68.0
Ret/OA	78.0	68.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	100	100
Infil	28	28
Supply	1,110	1,110
Mincfm	0	0
Return	1,238	1,238
Exhaust	128	128
Rm Exh	0	0
Auxil	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	9.0	9.0
cfm/sq ft	3.97	3.97
cfm/ton	1,376.67	
sq ft/ton	347.17	
Btu/hr-sq ft	34.56	-47.20
No. People	5	

COOLING COIL SELECTION

	Total Capacity tons	Total Capacity MBh	Sens Cap. MBh	Coil Airfl cfm	Enter DB F	Enter WB F	Enter HR gr/lb	Leave DB F	Leave WB F	Leave HR gr/lb
Main Clg	0.7	8.6	9.7	1,110	78.0	60.3	67.7	68.0	57.5	70.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.1	1.1	1.1	100	87.0	56.0	32.7	75.0	51.7	32.8
Totals	0.8	9.7								

AREAS

	Gross Total	Glass sq ft	Glass (%)
Floor	280		
Part	0		
ExFlr	0		
Roof	280	0	0
Wall	390	67	17

HEATING COIL SELECTION

	Capacity MBh	Coil Airfl cfm	Ent F	Lvg F
Main Htg	-4.4	1,110	68.0	72.3
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	0.0	0	0.0	0.0
Humidif	-3.4	128	3.5	50.0
Opt Vent	-5.4	100	5.0	65.0
Total	-13.2			

P. References

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Beall, Christine. Thermal and Moisture Protection Manual. McGraw, Hill. New York. 1999

ASHRAE Design/Data Manual for Closed-Loop Ground-Coupled Heat Pump Systems. 1985

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Websites:

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www.pnl.gov

www.globalchange.org

www.bellgossett.com

Electrical System Appendix

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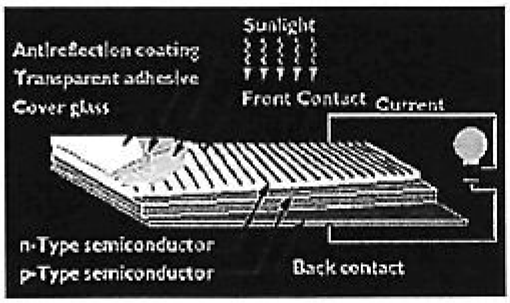
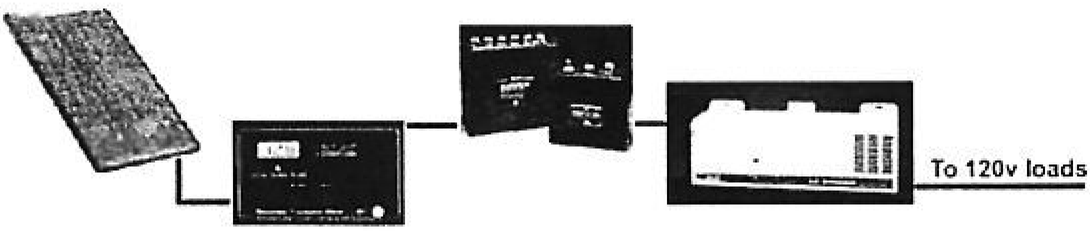
Electrical Appendix

Solar Cell Materials

The solar cells consist of two semiconductor layers that are used to produce the electron current. The detail in Figure 1 shows the components of each individual cell. A metal grid is adhered to the top of the semiconducting layers where it collects the electrons that are produced from the semiconductors. The electrons are then transferred to the desired building load and returned to the back of the contact layer. The back contact layer is necessary to complete the circuit. The glass cover is used to prevent any damage to the cell. The anti-reflective coating is used to prevent light from being reflected away from the cell.



System Components



There are several components of a photovoltaic system that are required to produce energy shown in Figure 2. The system starts with an array of photovoltaic cells that produce electricity. The electricity is transferred through the charge controller and stored in the batteries. The charge controller is used to eliminate the flow to the battery once the battery has reached its maximum capacity. The downfall of photovoltaic cells is they only produce direct current electricity. Direct current electricity (DC) is useful in powering the outdoor lighting. For all building applications and appliances alternating current electricity (AC) must be used. An inverter is used to convert the DC electricity to AC electricity where it can be used and supplied throughout the building.

Electrical Appendix

Solar Map

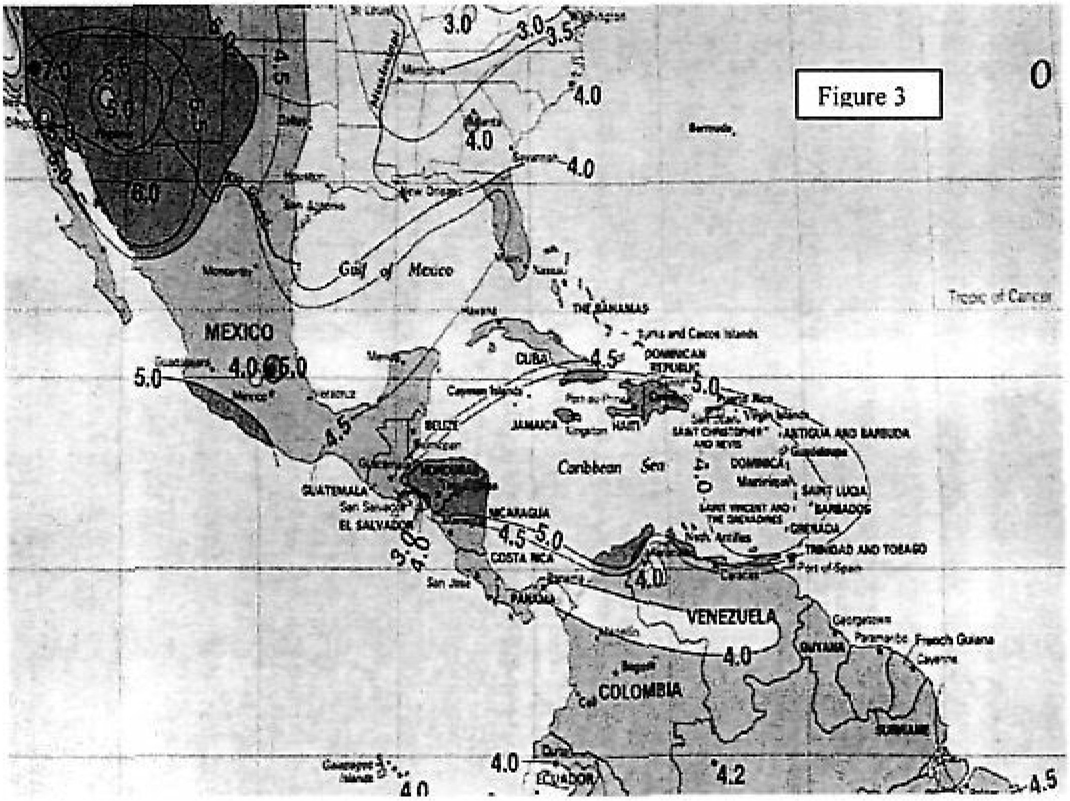


Figure 3

For solar power to be a worthwhile investment your location must have a high solar insolation value, for St. Michael's the value is 5.5. The values for the Southern United States can be viewed on the map above in Figure 3.

Electrical System Design

The decisions made by FBM Design for our client, St. Michael's Association for Special Education, Inc., provide the most feasible and efficient electrical system. The initial costs were compared with the long-term maintenance costs and a final system design was chosen. The chosen electrical system must be able to support 509,051.7 kWh per year. The electrical system consists of a primary 13,200 volt service coming in from the utility grid provided by the Navajo Tribal Utility Authority (NTUA). The service will then pass through the meter. After passing through the meter, the voltage will be stepped down via a 277/480 volt transformer. Once the power has been stepped down it will pass through a substation, breaking off to mechanical panel and a 120/208 transformer. Keep in mind all power both 277/480 and 120/208 or both 3 phases services, only at the switchboard were 120/240 volt service is separated using one of the legs of the 120/208 does the power become single phase. The switchboard has a lighting, auxiliary, and emergency panel. The system also integrates the use of solar power at the switchboard to power the single-phase auxiliary power needs. Also incorporated is a generator for the emergency power. A complete system schematic is viewable in the back of this appendix.

Integrated Solar Powered System

The solar powered system will be used to power just the single-phase auxiliary power as mentioned above. The needs of the systems to do so are 310 solar panels, 68 batteries and 8 inverters. The system will store energy in the batteries when the auxiliary power does not require the total amount of energy supplied from the panels.

Solar Powered Exterior Lighting

The exterior solar lighting is a feasible alternative because it required direct current power. The photovoltaic cells generate the DC power, eliminating the need for an inverter allowing it to be cost effective. The solar power generated during the day is stored in batteries and used to power the lights at night. These self-contained units will meet St. Michael's needs and will be implemented in the parking lot and also the sides of the building.

Emergency Back-up Power

The emergency power will use a 6500 watt generator if power fails in the building. The system begins with an automatic transfer switch (ATS) that controls if no power is coming through the utility grid it will switch to emergency power and the generator will be turned on. Once the generator is supplying power it will pass through the emergency panel and will be used for powering the emergency lighting and any other applications that SMASE specifies.

Electrical Appendix

Introduction

This appendix will contain detailed literature on the final electrical system design to be used at St. Michael's, Arizona. Included is a brief overview of how photovoltaics produce energy and how this phenomenon can be used to benefit St. Michaels. An electrical schematic will also be included to help present the layout of the electrical system. Emergency Power and Solar Powered Exterior Lighting will also be discussed. Lastly, a cost estimate will be included as well as all the building's solar, non-solar and lighting calculations.

Solar Energy

Photovoltaic Concepts

Photovoltaics are a technology that uses solar energy to produce electricity directly from sunlight. The largest benefit of using photovoltaics is that it is a clean way to produce energy. The cost of installing these solar panels are not expensive because they come prepackaged ready to implement, eliminating the need for skilled labor. They also have no moving parts eliminating the need for maintenance. Also new panels can be installed increase power in the existing systems. One downfall of photovoltaics is that there is not enough hard evidence to prove the durability to withstand extremes in the environment. A question that is asked is, "will the system produce enough energy to be worth the cost of installation." The answer to that question is dependent on the location. Also the current cost of a module is ranging from $4.00 to $10.00 per peak watt. A peak watt is the amount of electricity produced by a single cell when bright sunlight is available. The current photovoltaic cells are functioning at only 12% efficiency but the new silicon solar cells are more than 30% efficient. With the time frame for possible construction, the cells are a very possible alternative.

Electrical Appendix

Total Building Load Calculations

The calculations for the total building load were calculated from the summation of common household appliances and mechanical system components that will be found in our building. The electrical loads for the appliances were found at www.homepower.com. The mechanical loads are educated guesses from comparable cutsheets found on the Internet. The running time duration for all mechanical equipment is estimated to be operating at 24 hours a day, 7 days a week to obtain the total maximum load. A detailed breakdown is shown on the following page.

Electrical Appendix

Total Building Consumption

Quantity	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours/Day	Days/Week	W-hrs/day
1	*Well Pump*	1	*1300*	*3900*	*8.00*	*7.00*	*10400.0*
1	19 ft^3 Fridge/Freezer	1	120	240	10.00	7.00	1200.0
12	Televisions	0	75	200	4.00	5.00	2571.4
12	VCRs	0	40	40	2.00	5.00	685.7
35	Computers, Monitors, Peripherals	1	200	400	8.00	5.00	40000.0
20	Stereos	1	25	25	8.00	5.00	2857.1
2000	Compact Flourescent Lights	1	15	15	12.00	7.00	360000.0
1	Scanner	0	20	50	0.25	1.00	0.7
10	Printers	0	100	100	2.00	5.00	1428.6
12	Microwave Ovens	1	1000	2000	0.25	5.00	2142.9
4	Vacuum Cleaner	0	1350	2700	0.50	2.00	771.4
3	Washing Machine	1	300	525	1.25	5.00	803.6
3	Dryer	1	300	525	1.25	5.00	803.6
1	Fax	1	5	5	24.00	7.00	120.0
10	Power Tools	0	1350	2700	0.20	2.00	771.4
4	Coffee Maker	0	1200	1200	0.50	5.00	1714.3
3	Vending Machines	1	800	1000	24.00	7.00	57600.0
1	Toaster	0	1200	1200	0.25	1.00	42.9
1	Ni-Cad Battery Recharger	1	20	20	6.00	3.00	51.4
2	Copier	1	700	1200	3.00	5.00	3000.0
1	Sewing Machines	0	80	160	5.00	0.50	28.6
1	Blender	0	350	700	0.05	5.00	12.5
1	Coffee Grinder	0	150	300	0.05	5.00	5.4
1	Garbage Dispossal	0	900	900	0.25	5.00	160.7
1	Dishwasher	0	1000	1000	2.00	5.00	1428.6
1	Deep Freezer	1	500	1500	24.00	7.00	12000.0
1	Wireless Network Equipment	1	100	100	24.00	7.00	2400.0
1	Water Heater	1	5000	5000	24.00	7.00	120000.0
1	Recirculation Pump (3/4)	1	400	600	24.00	7.00	9600.0
40	Water Source Heat Pumps	1	400	525	24.00	7.00	384000.0
2	Therapy Pools	1	1500	2000	8.00	4.50	15428.6
10	Make-up Air Units	1	1000	1500	24.00	7.00	240000.0
2	Refrigerant Pumps	1	400	600	24.00	7.00	19200.0
8	Exhaust Fans	1	250	400	24.00	7.00	48000.0
3	Kitchen Hoods	1	200	350	2.00	5.00	857.1
1	Back-up Boiler	1	5000	5000	0.25	1.00	178.6
1	HVAC Controls	1	100	100	24.00	7.00	2400.0
1	Controls	1	100	100	24.00	7.00	2400.0
1	Phase Converter	1	250	400	24.00	7.00	6000.0
1	L&I Kiln J18X	1	8300	8300	8.00	5.00	47428.6
							1398493.7

*** Kitchen Ovens and Stoves will be powered by gas**

Total Building Load 509051.7 kWh/yr

Electrical Appendix

Solar Load Calculations

FBM Design used a spreadsheet provided online by www.homepower.com to perform all solar load calculations. Initially, the building load must be known to determine the quantities of solar panels and inverters along with the number of trackers. The initial calculation used the entire building load to determine the quantities of solar equipment. To power the whole building using solar, the total building would exceed 585,150 kWh for both AC and DC. The building would require 2244 panels, 480 batteries and has an initial cost of hardware exceeding $1.53 million.

We found this alternative not to be feasible. We feel that the solar power could provide sufficient power for all single-phase power needs. After running the simulation based on just single-phase AC loads, the building would require just 310 panels and 68 batteries and would cost $264,150.00. We feel this alternative is feasible and this will be implemented into our design. The actual load calculations can be found on the following pages.

Electrical Appendix

TOTAL BUILDING LOAD CALCULATIONS

INVERTER SUPPLIED 120 VAC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System
Home Power Magazine
St. Michaels, Arizona
Phone #

Date: 3/1/2001

AC Watt-hrs. Used Daily 1594726

Please note: this is an estimate and is only as good as the information supplied.

All Appliances on the list below are powered by 120 Volt - AC from the inverter

No.	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours /Day	Days /Week	W-hrs/day	%
1	Well Pump 1/2 hp, 120 VAC	1	1300	3900	1.25	7.00	1625.0	0.10%
1	19 cu ft Fridge/Freezer	1	120	240	10.00	7.00	1200.0	0.07%
12	TV	0	75	200	4.00	5.00	2571.4	0.16%
12	VCRs	0	40	40	2.00	5.00	685.7	0.04%
35	Computer, Monitor, Peripherals	1	200	400	8.00	5.00	40000.0	2.50%
20	Stereos	1	25	25	8.00	5.00	2857.1	0.18%
2000	Compact Fluorescent Lights	1	15	15	12.00	7.00	360000.0	22.46%
1	Scanner	0	20	50	0.25	1.00	0.7	0.00%
10	Printers	0	100	100	2.00	5.00	1428.6	0.09%
12	Microwave Oven	1	1000	2000	0.25	5.00	2142.9	0.13%
4	Vacuum Cleaner	0	1350	2700	0.50	2.00	771.4	0.05%
3	Washing Machine	1	300	525	1.25	5.00	803.6	0.05%
3	Dryer	1	300	525	1.25	5.00	803.6	0.05%
1	Fax	1	5	5	24.00	7.00	120.0	0.01%
10	Power Tools	0	1350	2700	0.20	2.00	771.4	0.05%
4	Coffee Maker	0	1200	1200	0.50	5.00	1714.3	0.11%
3	Vending Machines	1	800	1000	24.00	7.00	57600.0	3.59%
1	Toaster	0	1200	1200	0.25	1.00	42.9	0.00%
1	Ni-Cad Battery Recharger	1	20	20	6.00	3.00	51.4	0.00%
2	Copiers	1	700	1200	3.00	5.00	3000.0	0.19%
1	Sewing Machine	0	80	160	5.00	0.50	28.6	0.00%
1	Blender	0	350	700	0.05	5.00	12.5	0.00%
1	Coffee Grinder	0	150	300	0.05	5.00	5.4	0.00%
1	Garbage Disposal	0	900	900	0.25	5.00	160.7	0.01%
1	Dishwasher	0	1000	1000	2.00	5.00	1428.6	0.09%
1	Deep Freezer	1	500	1500	24.00	7.00	12000.0	0.75%
1	Wireless Network Equipment	1	100	100	24.00	7.00	2400.0	0.15%
1	Water Heater	0	5000	5000	24.00	7.00	120000.0	7.49%
1	Recirculation Pump (1/8)	1	275	400	24.00	7.00	6600.0	0.41%
40	Water Source Heat Pump	1	400	525	24.00	7.00	384000.0	23.96%
2	Therapy Pools	1	1500	2000	8.00	4.50	15428.6	0.96%
10	Make-up Air Units	1	1000	1500	24.00	7.00	240000.0	14.97%
2	Refrigerant Pump	1	400	600	24.00	7.00	19200.0	1.20%
8	*Exhaust Fans*	*1*	*250*	*400*	*24.00*	*7.00*	*48000.0*	*2.99%*
3	Kitchen Hoods	1	200	350	2.00	5.00	857.1	0.05%
1	Back-up Boiler	1	5000	5000	0.25	1.00	178.6	0.01%
1	HVAC Controls	1	100	100	24.00	7.00	2400.0	0.15%
1	Controls	1	100	100	24.00	7.00	2400.0	0.15%
1	Phase Converter	1	250	400	24.00	7.00	6000.0	0.37%
1	L&L Kiln J18X	1	8300	8300	8.00	5.00	47428.6	2.96%

DC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System
Home Power Magazine
St. Michaels, Arizona
Phone #

Date: 3/1/2001

DC W.-hrs. Used Daily 8424

All appliances on the list below are DC powered directly from the batteries

No.	DC Powered Appliance	Wattage	On Time	Watt-hrs/day	%
27	Inverter idle draw (on)	13	24	8424	0.5%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%

Total DC Watt-hours Consumed Daily 8424

10

Total estimated energy consumption daily-both DC and AC

1603150.38 Watt-hours per day

Consumption for Link 1603150.38 Watt-hours daily

Inverter Presence? 1 1 is yes and 0 is no

Inverter surge Wattage needed 80000 Watts

Inverter priority Wattage needed 147720 Watts

Electrical Appendix

TOTAL BUILDING LOAD CALCULATIONS

THE CONTROL PANEL

Energy Efficient Home System — Date 3/1/2001
Home Power Magazine
St. Michaels, Arizona
Phone #

THE FACTS OF THE MATTER

Computer Determined Data based on User's Consumption Estimate

Consumption	1,603,150 Watt-hours/day	Inverter Size	148,500 Watts
Battery Voltage	24 Volts	Battery Capacity	42,000 Ampere-hours
Solar Increment	2 Panels	Optimum Solar	2244 Panels
C/20 Solar	574 Panels	Stand Alone Solar	2916 Panels
Solar Watts	224000 Watts	Solar Insolation	5.5 hours per day

USER INPUT– THE CONTROLS

Battery Storage	0.5 days	DC Generator	0 Watts
AC Generator	8500 Watts	Solar	2240 Panels
		Tracker?	1 1 if true, else 0

THE BOTTOM LINE

Battery Storage	0.50 days	Average Storage	2.20 days
System Op.Cost	$3561.16 per month	Generator Time	2595 Hours/year
Leftover Power	163,300 Watts	Solar Power	99.90% of Consumption

Initial Cost	$1,531,211.00 for hardware	Operating Cost	$42613.97 per year
Cost per year	$195,735.07 @10 year basis	Power Cost	$0.335 per kW.-hr.
Cost per month	$16,311.26 @10 year basis		
Total Cost	$1,957,350.71 @10 year basis		

RENEWABLE ENERGY SYSTEM HARDWARE COST ESTIMATE for
Energy Efficient Home System — Date: 3/1/2001
Home Power Magazine
St. Michaels, Arizona
Phone # — Power Consumption 1603150.4 Watt-hours/day

Initial Cost Estimate $1531211.00

No.	Item Description	Type	Unit Price	Shipping @	Item Total	% of Cost
2240	Siemens PV modules	SR 100	$525.00	$0.00	$1,176,000.00	76.80%
12	Trace Inverter	SW4024	$3,000.00	$0.00	$36,000.00	2.35%
480	Trojan Batteries	L-16	$150.00	$0.00	$72,000.00	4.70%
1	AC Generator	8500	$3,000.00	$0.00	$3,000.00	0.20%
1000	Installation Labor per man-hour	estimate	$50.00	$0.00	$50,000.00	3.27%
560	PV Mounting Rack	4-SR100	$220.00	$0.00	$123,200.00	8.05%
27	Solar Boost Charge Controller	SB50	$330.00	$0.00	$8,910.00	0.58%
1	Wire, Conduit, Fittings	estimate	$50,000.00	$0.00	$50,000.00	3.27%
27	Battery/Inverter Fused Discon.	DC-250	$329.00	$0.00	$8,883.00	0.58%
852	Battery/Inverter Cables	estimate	$300.00	$0.00	$300.00	0.02%
1	Battery Amp-hour Meter	E-Meter	$200.00	$0.00	$200.00	0.01%
2	Fused PV Disconnect	Sq. D	$60.00	$0.00	$120.00	0.01%
27	Inverter Conduit Box	SWCB	$94.00	$0.00	$2,538.00	0.17%
2	DC Lightning Arrestor	Delta	$30.00	$0.00	$60.00	0.00%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%

Total Initial Hardware Cost Estimate $1,531,211.00

Electrical Appendix

FEASIBLE BUILDING LOAD CALCULATIONS

INVERTER SUPPLIED 120 VAC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System
Home Power Magazine
St. Michaels, Arizona
Phone #

Date: 3/1/2001

AC Watt-hrs. Used Daily 215788

Please note: this is an estimate and is only as good as the information supplied.

All Appliances on the list below are powered by 120 Volt - AC from the inverter

No.	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours /Day	Days /Week	W-hrs/day	%
1	Well Pump 1/2 hp, 120 VAC	1	1300	3900	1.25	7.00	1625.0	0.74%
1	18 cu ft Fridge/Freezer	1	170	240	10.00	7.00	1700.0	0.78%
12	TV	0	75	200	4.00	5.00	2571.4	1.17%
12	VCRs	0	40	40	2.00	5.00	685.7	0.31%
35	Computer, Monitor, Peripherals	1	200	400	8.00	5.00	40000.0	18.24%
20	Stereos	1	25	25	8.00	5.00	2857.1	1.30%
2000	Compact Fluorescent Lights	1		15	12.00	7.00	0.0	0.00%
1	Scanner	0	20	50	0.25	1.00	0.7	0.00%
10	Printers	0	100	100	2.00	5.00	1428.6	0.65%
12	Microwave Oven	1	1000	2000	0.25	5.00	2142.9	0.98%
4	Vacuum Cleaner	0	1350	2700	0.50	2.00	771.4	0.35%
3	Washing Machine	1	300	525	1.25	5.00	803.6	0.37%
3	Dryer	1	300	525	1.25	5.00	803.6	0.37%
1	Fax	1	5	5	24.00	7.00	120.0	0.05%
10	Power Tools	0	1350	2700	0.20	2.00	771.4	0.35%
4	Coffee Maker	0	1200	1200	0.50	5.00	1714.3	0.78%
3	Vending Machines	1	800	1000	24.00	7.00	57600.0	26.27%
1	Toaster	0	1200	1200	0.25	1.00	42.9	0.02%
1	Ni-Cad Battery Recharger	1	20	20	6.00	3.00	51.4	0.02%
2	Copiers	1	700	1200	3.00	5.00	3000.0	1.37%
1	Sewing Machine	0	80	160	5.00	0.50	28.6	0.01%
1	Blender	0	350	700	0.05	5.00	12.5	0.01%
1	Coffee Grinder	0	150	300	0.05	5.00	5.4	0.00%
1	Garbage Disposal	0	900	900	0.25	5.00	160.7	0.07%
1	Dishwasher	0	1000	1000	2.00	5.00	1428.6	0.65%
1	Deep Freezer	1	500	1500	24.00	7.00	12000.0	5.47%
1	Wireless Network Equipment	1	100	100	24.00	7.00	2400.0	1.09%
1	Water Heater	0		5000	24.00	7.00	0.0	0.00%
1	Recirculation Pump (3/4)	1		400	24.00	7.00	0.0	0.00%
40	Water Source Heat Pump	1		525	24.00	7.00	0.0	0.00%
2	Therapy Pools	1		2000	8.00	4.50	0.0	0.00%
10	Make-up Air Units	1		1500	24.00	7.00	0.0	0.00%
2	Refrigerant Pump	1		800	24.00	7.00	0.0	0.00%
8	Exhaust Fans	1		400	24.00	7.00	0.0	0.00%
3	Kitchen Hoods	1	200	350	2.00	5.00	857.1	0.39%
1	Back-up Boiler	1		5000	0.25	1.00	0.0	0.00%
1	HVAC Controls	1		100	24.00	7.00	0.0	0.00%
1	Controls	1		100	24.00	7.00	0.0	0.00%
1	Phase Converter	1	250	400	24.00	7.00	6000.0	2.74%
1	L&L Kiln J18X	1	8300	8300	8.00	5.00	47428.6	21.63%

DC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System
Home Power Magazine
St. Michaels, Arizona
Phone #

Date: 3/1/2001

DC W.-hrs. Used Daily 2496

All appliances on the list below are DC powered directly from the batteries

No.	DC Powered Appliance	Wattage	On Time	Watt-hrs/day	%
8	Inverter idle draw (on)	13	24	2496	1.1%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%

Total DC Watt-hours Consumed Daily 2496

10

Total estimated energy consumption daily-both DC and AC

219284.14 Watt-hours per day

Consumption for Link 219284.14 Watt-hours daily

Inverter Presence? 1 1 is yes and 0 is no

Inverter surge Wattage needed 60000 Watts

Inverter priority Wattage needed 35345 Watts

Electrical Appendix

FEASIBLE BUILDING LOAD CALCULATIONS

THE CONTROL PANEL

Energy Efficient Home System — Date 3/1/2001
Home Power Magazine
St. Michaels, Arizona
Phone #

THE FACTS OF THE MATTER

Computer Determined Data based on User's Consumption Estimate

Consumption	219,264	Watt-hours/day	Inverter Size	44,000	Watts
Battery Voltage	24	Volts	Battery Capacity	5,850	Ampere-hours
Solar Increment	2	Panels	Optimum Solar	308	Panels
C/20 Solar	98	Panels	Stand Alone Solar	404	Panels
Solar Watts	31000	Watts	Solar Insolation	5.5	hours per day

USER INPUT— THE CONTROLS

Battery Storage	0.5	days	DC Generator	0	Watts
AC Generator	6500	Watts	Solar	310	Panels
			Tracker?	1	1 if true, else 0

THE BOTTOM LINE

Battery Storage	0.52	days	Average Storage	2.29	days
System Op Cost	$551.63	per month	Generator Time	2499	Hours/year
Leftover Power	27,980	Watts	Solar Power	101.08%	of Consumption

Initial Cost	$264,150.00	for hardware	Operating Cost	$6619.59	per year
Cost per year	$33,034.59	@10 year basis	Power Cost	$0.413	per kW.-hr.
Cost per month	$2,752.88	@10 year basis			
Total Cost	$330,345.92	@10 year basis			

RENEWABLE ENERGY SYSTEM HARDWARE COST ESTIMATE for
Energy Efficient Home System — Date: 3/1/2001
Home Power Magazine
St. Michaels, Arizona
Phone # — Power Consumption 219284.14 Watt-hours/day

Initial Cost Estimate $264150.00

No.	Item Description	Type	Unit Price	Shipping @	Item Total	% of Cost
310	Siemens PV modules	SR 100	$525.00	$0.00	$162,750.00	61.61%
8	Trace Inverter	SW4024	$3,000.00	$0.00	$24,000.00	9.09%
68	Trojan Batteries	L-16	$150.00	$0.00	$10,200.00	3.86%
1	AC Generator	6500	$3,000.00	$0.00	$3,000.00	1.14%
320	Installation Labor per man-hour	estimate	$50.00	$0.00	$16,000.00	6.06%
78	PV Mounting Rack	4-SR100	$220.00	$0.00	$17,160.00	6.50%
2	Solar Boost Charge Controller	SB50	$330.00	$0.00	$660.00	0.25%
1	Wire, Conduit, Fittings	estimate	$25,000.00	$0.00	$25,000.00	9.46%
12	Battery/Inverter Fused Discon.	DC-250	$329.00	$0.00	$3,948.00	1.49%
59	Battery/Inverter Cables	estimate	$300.00	$0.00	$300.00	0.11%
1	Battery Amp-hour Meter	E-Meter	$200.00	$0.00	$200.00	0.08%
2	Fused PV Disconnect	Sq. D	$60.00	$0.00	$120.00	0.05%
8	Inverter Conduit Box	SWCB	$94.00	$0.00	$752.00	0.28%
2	DC Lightning Arrestor	Delta	$30.00	$0.00	$60.00	0.02%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%

Total Initial Hardware Cost Estimate $264,150.00

Electrical Appendix

Cost Estimate

The cost estimate is based on the hardware determined and specified on the spreadsheet. These products and any useful information can be viewable at www.solar4power.com. The following is a summary from the calculated simulation.

Initial Cost of Solar Powered System	*$264,150.00*
Estimated Cost of Overall Electrical System w/o Solar Power	*$200,000.00*
TOTAL	**$465,150.00**

The following numbers are a direct relation to the initial cost of the solar-powered system. Such as, the operating cost totaling $551.43 per month. The power cost is equal to $0.413 per kWh. Finally, an excess power wattage of 27,980 watts will be in excess.

Insert
Electrical Schematic
Here

Electrical Appendix

Lighting

Preliminary lighting calculations were made using the zonal cavity method. The specified fluorescent lamp has the following characteristics:

32 watts, T-8, 4100 K, 85 CRI, 2900 design lumens

The luminaire selected was the Simkar prismatic lens.

Room Demensions: Typical Classroom – 75' x 35'

Ceiling Height – 10'

Work Surface Height – 2.5'

RCR = [5*(CH-WSH)(L+W)]/(L*W)

= [5*(10-2.5)(75+35)]/(75*35)

= 1.57

From Simkar Lighting Catalog:

@RCR = 1, CU = 80

@RCR = 2, CU = 71

Linear Interpolation:

(2-1.57)/(2-1) = (71-CU)/(71-80)

CU = 72.9

Luminaires = (fc*area)/[(lumens/lamp)(lamps/luminaire)(CU)(LLF)]

= (75*2625)/[(2900)(4)(0.73)(.7)]

= 32.2 = 33

This calculation shows that 33 luminaires will be required in a typical classroom with a cost of $0.55 watt/SF.

Electrical Appendix

Resources/References

1. www.pvpower.com
2. www.solar4power.com
3. www.solarenergy.com
4. www.flasolar.com
5. www.eren.doe.gov/power/
6. www.seia.org
7. www.solarelectric.com
8. www.eren.gov/wind/
9. www.cogreenpower.org
10. www.homepower.com
11. www.solarlighting.com
12. www.hotkilns.com
13. www.powerq.com/watt.htm
14. www.angelfire.com/nc2
15. http://www.sandia.gov/media/NewsRel/nr2000/navajos.htm
16. 1997 Simkar Lighting Catalog
17. 1998 Osram Sylvania Lamp and Ballast Catalog

Electrical System Appendix

Table of Contents

Electrical Appendix

Introduction

This appendix will contain detailed literature on the final electrical system design to be used at St. Michael's, Arizona. Included is a brief overview of how photovoltaics produce energy and how this phenomenon can be used to benefit St. Michaels. An electrical schematic will also be included to help present the layout of the electrical system. Emergency Power and Solar Powered Exterior Lighting will also be discussed. Lastly, a cost estimate will be included as well as all the building's solar, non-solar and lighting calculations.

Solar Energy

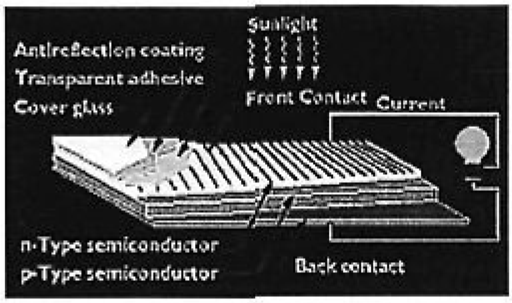
Photovoltaic Concepts

Photovoltaics are a technology that uses solar energy to produce electricity directly from sunlight. The largest benefit of using photovoltaics is that it is a clean way to produce energy. The cost of installing these solar panels are not expensive because they come prepackaged ready to implement, eliminating the need for skilled labor. They also have no moving parts eliminating the need for maintenance. Also new panels can be installed increase power in the existing systems. One downfall of photovoltaics is that there is not enough hard evidence to prove the durability to withstand extremes in the environment. A question that is asked is, "will the system produce enough energy to be worth the cost of installation." The answer to that question is dependent on the location. Also the current cost of a module is ranging from $4.00 to $10.00 per peak watt. A peak watt is the amount of electricity produced by a single cell when bright sunlight is available. The current photovoltaic cells are functioning at only 12% efficiency but the new silicon solar cells are more than 30% efficient. With the time frame for possible construction, the cells are a very possible alternative.

Electrical Appendix

Solar Cell Materials

The solar cells consist of two semiconductor layers that are used to produce the electron current. The detail in Figure 1 shows the components of each individual cell. A metal grid is adhered to the top of the semiconducting layers where it collects the electrons that are produced from the semiconductors. The electrons are then transferred to the desired building load and returned to the back of the contact layer. The back contact layer is necessary to complete the circuit. The glass cover is used to prevent any damage to the cell. The anti-reflective coating is used to prevent light from being reflected away from the cell.



System Components

There are several components of a photovoltaic system that are required to produce energy shown in Figure 2. The system starts with an array of photovoltaic cells that produce electricity. The electricity is transferred through the charge controller and stored in the batteries. The charge controller is used to eliminate the flow to the battery once the battery has reached its maximum capacity. The downfall of photovoltaic cells is they only produce direct current electricity. Direct current electricity (DC) is useful in powering the outdoor lighting. For all building applications and appliances alternating current electricity (AC) must be used. An inverter is used to convert the DC electricity to AC electricity where it can be used and supplied throughout the building.

Electrical Appendix

Solar Map

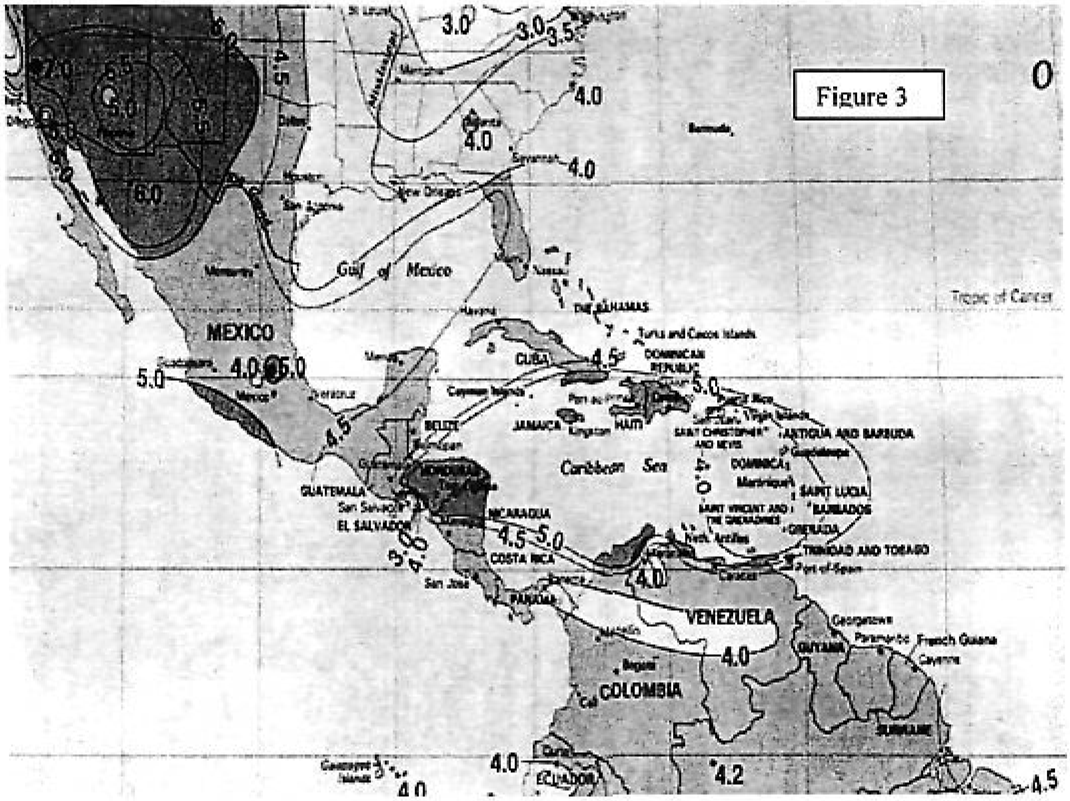


Figure 3

For solar power to be a worthwhile investment your location must have a high solar insolation value, for St. Michael's the value is 5.5. The values for the Southern United States can be viewed on the map above in Figure 3.

Electrical System Design

The decisions made by FBM Design for our client, St. Michael's Association for Special Education, Inc., provide the most feasible and efficient electrical system. The initial costs were compared with the long-term maintenance costs and a final system design was chosen. The chosen electrical system must be able to support 509,051.7 kWh per year. The electrical system consists of a primary 13,200 volt service coming in from the utility grid provided by the Navajo Tribal Utility Authority (NTUA). The service will then pass through the meter. After passing through the meter, the voltage will be stepped down via a 277/480 volt transformer. Once the power has been stepped down it will pass through a substation, breaking off to mechanical panel and a 120/208 transformer. Keep in mind all power both 277/480 and 120/208 or both 3 phases services, only at the switchboard were 120/240 volt service is separated using one of the legs of the 120/208 does the power become single phase. The switchboard has a lighting, auxiliary, and emergency panel. The system also integrates the use of solar power at the switchboard to power the single-phase auxiliary power needs. Also incorporated is a generator for the emergency power. A complete system schematic is viewable in the back of this appendix.

Integrated Solar Powered System

The solar powered system will be used to power just the single-phase auxiliary power as mentioned above. The needs of the systems to do so are 310 solar panels, 68 batteries and 8 inverters. The system will store energy in the batteries when the auxiliary power does not require the total amount of energy supplied from the panels.

Solar Powered Exterior Lighting

The exterior solar lighting is a feasible alternative because it required direct current power. The photovoltaic cells generate the DC power, eliminating the need for an inverter allowing it to be cost effective. The solar power generated during the day is stored in batteries and used to power the lights at night. These self-contained units will meet St. Michael's needs and will be implemented in the parking lot and also the sides of the building.

Emergency Back-up Power

The emergency power will use a 6500 watt generator if power fails in the building. The system begins with an automatic transfer switch (ATS) that controls if no power is coming through the utility grid it will switch to emergency power and the generator will be turned on. Once the generator is supplying power it will pass through the emergency panel and will be used for powering the emergency lighting and any other applications that SMASE specifies.

Electrical Appendix

Total Building Load Calculations

The calculations for the total building load were calculated from the summation of common household appliances and mechanical system components that will be found in our building. The electrical loads for the appliances were found at www.homepower.com. The mechanical loads are educated guesses from comparable cutsheets found on the Internet. The running time duration for all mechanical equipment is estimated to be operating at 24 hours a day, 7 days a week to obtain the total maximum load. A detailed breakdown is shown on the following page.

Electrical Appendix

Total Building Consumption

Quantity	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours/Day	Days/Week	W-hrs/day
1	Well Pump	1	1300	3900	8.00	7.00	10400.0
1	19 ft^3 Fridge/Freezer	1	120	240	10.00	7.00	1200.0
12	Televisions	0	75	200	4.00	5.00	2571.4
12	VCRs	0	40	40	2.00	5.00	685.7
35	Computers, Monitors, Peripherals	1	200	400	8.00	5.00	40000.0
20	Stereos	1	25	25	8.00	5.00	2857.1
2000	Compact Flourescent Lights	1	15	15	12.00	7.00	360000.0
1	Scanner	0	20	50	0.25	1.00	0.7
10	Printers	0	100	100	2.00	5.00	1428.6
12	Microwave Ovens	1	1000	2000	0.25	5.00	2142.9
4	Vacuum Cleaner	0	1350	2700	0.50	2.00	771.4
3	Washing Machine	1	300	525	1.25	5.00	803.6
3	Dryer	1	300	525	1.25	5.00	803.6
1	Fax	1	5	5	24.00	7.00	120.0
10	Power Tools	0	1350	2700	0.20	2.00	771.4
4	Coffee Maker	0	1200	1200	0.50	5.00	1714.3
3	Vending Machines	1	800	1000	24.00	7.00	57600.0
1	Toaster	0	1200	1200	0.25	1.00	42.9
1	Ni-Cad Battery Recharger	1	20	20	6.00	3.00	51.4
2	Copier	1	700	1200	3.00	5.00	3000.0
1	Sewing Machines	0	80	160	5.00	0.50	28.6
1	Blender	0	350	700	0.05	5.00	12.5
1	Coffee Grinder	0	150	300	0.05	5.00	5.4
1	Garbage Dispossal	0	900	900	0.25	5.00	160.7
1	Dishwasher	0	1000	1000	2.00	5.00	1428.6
1	Deep Freezer	1	500	1500	24.00	7.00	12000.0
1	Wireless Network Equipment	1	100	100	24.00	7.00	2400.0
1	Water Heater	1	5000	5000	24.00	7.00	120000.0
1	Recirculation Pump (3/4)	1	400	600	24.00	7.00	9600.0
40	Water Source Heat Pumps	1	400	525	24.00	7.00	384000.0
2	Therapy Pools	1	1500	2000	8.00	4.50	15428.6
10	Make-up Air Units	1	1000	1500	24.00	7.00	240000.0
2	Refrigerant Pumps	1	400	600	24.00	7.00	19200.0
8	Exhaust Fans	1	250	400	24.00	7.00	48000.0
3	Kitchen Hoods	1	200	350	2.00	5.00	857.1
1	Back-up Boiler	1	5000	5000	0.25	1.00	178.6
1	HVAC Controls	1	100	100	24.00	7.00	2400.0
1	Controls	1	100	100	24.00	7.00	2400.0
1	Phase Converter	1	250	400	24.00	7.00	6000.0
1	L&I Kiln J18X	1	8300	8300	8.00	5.00	47428.6
							1398493.7

*** Kitchen Ovens and Stoves will be powered by gas**

Total Building Load 509051.7 kWh/yr

Electrical Appendix

Solar Load Calculations

FBM Design used a spreadsheet provided online by www.homepower.com to perform all solar load calculations. Initially, the building load must be known to determine the quantities of solar panels and inverters along with the number of trackers. The initial calculation used the entire building load to determine the quantities of solar equipment. To power the whole building using solar, the total building would exceed 585,150 kWh for both AC and DC. The building would require 2244 panels, 480 batteries and has an initial cost of hardware exceeding $1.53 million.

We found this alternative not to be feasible. We feel that the solar power could provide sufficient power for all single-phase power needs. After running the simulation based on just single-phase AC loads, the building would require just 310 panels and 68 batteries and would cost $264,150.00. We feel this alternative is feasible and this will be implemented into our design. The actual load calculations can be found on the following pages.

Electrical Appendix

TOTAL BUILDING LOAD CALCULATIONS

INVERTER SUPPLIED 120 VAC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System
Home Power Magazine
St. Michaels, Arizona
Phone #

Date: 3/1/2001

AC Watt-hrs. Used Daily 1594726

Please note: this is an estimate and is only as good as the information supplied.

All Appliances on the list below are powered by 120 Volt - AC from the inverter

No.	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours /Day	Days /Week	W-hrs/day	%
1	Well Pump 1/2 hp. 120 VAC	1	1300	3900	1.25	7.00	1625.0	0.10%
1	19 cu ft Fridge/Freezer	1	120	240	10.00	7.00	1200.0	0.07%
12	TV	0	75	200	4.00	5.00	2571.4	0.16%
12	VCRs	0	40	40	2.00	5.00	685.7	0.04%
35	Computer, Monitor, Peripherals	1	200	400	8.00	5.00	40000.0	2.50%
20	Stereos	1	25	25	8.00	5.00	2857.1	0.18%
2000	Compact Fluorescent Lights	1	15	15	12.00	7.00	360000.0	22.46%
1	Scanner	0	20	50	0.25	1.00	0.7	0.00%
10	Printers	0	100	100	2.00	5.00	1428.6	0.09%
12	Microwave Oven	1	1000	2000	0.25	5.00	2142.9	0.13%
4	Vacuum Cleaner	0	1350	2700	0.50	2.00	771.4	0.05%
3	Washing Machine	1	300	525	1.25	5.00	803.6	0.05%
3	Dryer	1	300	525	1.25	5.00	803.6	0.05%
1	Fax	1	5	5	24.00	7.00	120.0	0.01%
10	Power Tools	0	1350	2700	0.20	2.00	771.4	0.05%
4	Coffee Maker	0	1200	1200	0.50	5.00	1714.3	0.11%
3	Vending Machines	1	800	1000	24.00	7.00	57600.0	3.59%
1	Toaster	0	1200	1200	0.25	1.00	42.9	0.00%
1	Ni-Cad Battery Recharger	1	20	20	6.00	3.00	51.4	0.00%
2	Copiers	1	700	1200	3.00	5.00	3000.0	0.19%
1	Sewing Machine	0	80	160	5.00	0.50	28.6	0.00%
1	Blender	0	350	700	0.05	5.00	12.5	0.00%
1	Coffee Grinder	0	150	300	0.05	5.00	5.4	0.00%
1	Garbage Disposal	0	900	900	0.25	5.00	160.7	0.01%
1	Dishwasher	0	1000	1000	2.00	5.00	1428.6	0.09%
1	Deep Freezer	1	500	1500	24.00	7.00	12000.0	0.75%
1	Wireless Network Equipment	1	100	100	24.00	7.00	2400.0	0.15%
1	Water Heater	0	5000	5000	24.00	7.00	120000.0	7.49%
1	Recirculation Pump (1/8)	1	275	400	24.00	7.00	6600.0	0.41%
40	Water Source Heat Pump	1	400	525	24.00	7.00	384000.0	23.95%
2	Therapy Pools	1	1500	2000	8.00	4.50	15428.6	0.96%
10	Make-up Air Units	1	1000	1500	24.00	7.00	240000.0	14.97%
2	Refrigerant Pump	1	400	600	24.00	7.00	19200.0	1.20%
8	Exhaust Fans	1	250	400	24.00	7.00	48000.0	2.99%
3	Kitchen Hoods	1	200	350	2.00	5.00	857.1	0.05%
1	Back-up Boiler	1	5000	5000	0.25	1.00	178.6	0.01%
1	HVAC Controls	1	100	100	24.00	7.00	2400.0	0.15%
1	Controls	1	100	100	24.00	7.00	2400.0	0.15%
1	Phase Converter	1	250	400	24.00	7.00	6000.0	0.37%
1	L&L Kiln J18X	1	8300	8300	8.00	5.00	47428.6	2.96%

DC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System
Home Power Magazine
St. Michaels, Arizona
Phone #

Date: 3/1/2001

DC W.-hrs. Used Daily 8424

All appliances on the list below are DC powered directly from the batteries

No.	DC Powered Appliance	Wattage	On Time	Watt-hrs/day	%
27	Inverter idle draw (on)	13	24	8424	0.5%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%

Total DC Watt-hours Consumed Daily 8424

10

Total estimated energy consumption daily-both DC and AC
1603150.36 Watt-hours per day
Consumption for Unit 1603150.36 Watt-hours daily
Inverter Presence? 1 1 is yes and 0 is no
Inverter surge Wattage needed 80000 Watts
Inverter priority Wattage needed 147720 Watts

Electrical Appendix

TOTAL BUILDING LOAD CALCULATIONS

THE CONTROL PANEL

Energy Efficient Home System — Date 3/1/2001

Home Power Magazine

St. Michaels, Arizona

Phone #

THE FACTS OF THE MATTER

Computer Determined Data based on User's Consumption Estimate

Consumption	1,603,150 Watt-hours/day	Inverter Size	148,500 Watts
Battery Voltage	24 Volts	Battery Capacity	42,000 Ampere-hours
Solar Increment	2 Panels	Optimum Solar	2244 Panels
C/20 Solar	674 Panels	Stand Alone Solar	2918 Panels
Solar Watts	224000 Watts	Solar Insolation	5.5 hours per day

USER INPUT – THE CONTROLS

Battery Storage	0.5 days	DC Generator	0 Watts
AC Generator	6500 Watts	Solar	2240 Panels
		Tracker?	1 (1 if true, else 0)

THE BOTTOM LINE

Battery Storage	0.50 days	Average Storage	2.20 days
System Op Cost	$3551.16 per month	Generator Time	2595 Hours/year
Leftover Power	153,300 Watts	Solar Power	99.90% of Consumption
Initial Cost	$1,531,211.00 for hardware	Operating Cost	$42613.97 per year
Cost per year	$195,735.07 @10 year basis	Power Cost	$0.335 per KW.-hr.
Cost per month	$16,311.26 @10 year basis		
Total Cost	$1,957,350.71 @10 year basis		

RENEWABLE ENERGY SYSTEM HARDWARE COST ESTIMATE for

Energy Efficient Home System — Date: 3/1/2001

Home Power Magazine

St. Michaels, Arizona

Phone #

Power Consumption 1603150.4 Watt-hours/day

Initial Cost Estimate $1531211.00

No.	Item Description	Type	Unit Price	Shipping @	Item Total	% of Cost
2240	Siemens PV modules	SR 100	$525.00	$0.00	$1,176,000.00	76.80%
12	Trace Inverter	SW4024	$3,000.00	$0.00	$36,000.00	2.35%
480	Trojan Batteries	L-16	$150.00	$0.00	$72,000.00	4.70%
1	AC Generator	6500	$3,000.00	$0.00	$3,000.00	0.20%
1000	Installation Labor per man-hour	estimate	$50.00	$0.00	$50,000.00	3.27%
560	PV Mounting Rack	4-SR100	$220.00	$0.00	$123,200.00	8.05%
27	Solar Boost Charge Controller	SB50	$330.00	$0.00	$8,910.00	0.58%
1	Wire, Conduit, Fittings	estimate	$50,000.00	$0.00	$50,000.00	3.27%
27	Battery/Inverter Fused Disconn.	DC-250	$329.00	$0.00	$8,883.00	0.58%
652	Battery/Inverter Cables	estimate	$300.00	$0.00	$300.00	0.02%
1	Battery Amp-hour Meter	E-Meter	$200.00	$0.00	$200.00	0.01%
2	Fused PV Disconnect	Sq. D	$60.00	$0.00	$120.00	0.01%
27	Inverter Conduit Box	SWCB	$94.00	$0.00	$2,538.00	0.17%
2	DC Lightning Arrestor	Delta	$30.00	$0.00	$60.00	0.00%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%

Total Initial Hardware Cost Estimate $1,531,211.00

FEASIBLE BUILDING LOAD CALCULATIONS

1

INVERTER SUPPLIED 120 VAC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System	Date: 3/1/2001
Home Power Magazine	
St. Michaels, Arizona	
Phone #	AC Watt-hrs. Used Daily 216788

Please note: this is an estimate and is only as good as the information supplied.

All Appliances on the list below are powered by 120 Volt - AC from the inverter

No.	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours /Day	Days /Week	Watt-hrs/day	%
1	Well Pump 1/2 hp. 120 VAC	1	1300	3900	1.25	7.00	1625.0	0.74%
1	19 cu ft Fridge/Freezer	1	120	240	10.00	7.00	1200.0	0.55%
12	TV	0	75	200	4.00	5.00	2571.4	1.17%
12	VCRs	0	40	40	2.00	5.00	685.7	0.31%
35	Computer, Monitor, Peripherals	1	200	400	8.00	5.00	40000.0	18.24%
20	Stereos	1	25	25	8.00	5.00	2857.1	1.30%
2000	Compact Fluorescent Lights	1		15	12.00	7.00	0.0	0.00%
1	Scanner	0	20	50	0.25	1.00	0.7	0.00%
10	Printers	0	100	100	2.00	5.00	1428.6	0.65%
12	Microwave Oven	1	1000	2000	0.25	5.00	2142.9	0.98%
4	Vacuum Cleaner	0	1350	2700	0.50	2.00	771.4	0.35%
3	Washing Machine	1	300	525	1.25	5.00	803.6	0.37%
3	Dryer	1	300	525	1.25	5.00	803.6	0.37%
1	Fax	1	5	5	24.00	7.00	120.0	0.05%
10	Power Tools	0	1350	2700	0.20	2.00	771.4	0.35%
4	Coffee Maker	0	1200	1200	0.50	5.00	1714.3	0.78%
3	Vending Machines	1	800	1000	24.00	7.00	57600.0	26.27%
1	Toaster	0	1200	1200	0.25	1.00	42.9	0.02%
1	Ni-Cad Battery Recharger	1	20	20	6.00	3.00	51.4	0.02%
2	Copiers	1	700	1200	3.00	5.00	3000.0	1.37%
1	Sewing Machine	0	30	100	5.00	0.50	26.8	0.01%
1	Blender	0	350	700	0.05	5.00	12.5	0.01%
1	Coffee Grinder	0	150	300	0.05	5.00	5.4	0.00%
1	Garbage Disposal	0	900	900	0.25	5.00	160.7	0.07%
1	Dishwasher	0	1000	1000	2.00	5.00	1428.6	0.65%
1	Deep Freezer	1	500	1500	24.00	7.00	12000.0	5.47%
1	Wireless Network Equipment	1	100	100	24.00	7.00	2400.0	1.09%
1	Water Heater	0		5000	24.00	7.00	0.0	0.00%
1	Recirculation Pump (3/4)	1		400	24.00	7.00	0.0	0.00%
40	Water Source Heat Pump	1		525	24.00	7.00	0.0	0.00%
2	Therapy Pools	1		2000	8.00	4.50	0.0	0.00%
10	Make-up Air Units	1		1500	24.00	7.00	0.0	0.00%
2	Refrigerant Pump	1		600	24.00	7.00	0.0	0.00%
6	Exhaust Fans	1		400	24.00	7.00	0.0	0.00%
3	Kitchen Hoods	1	200	350	2.00	5.00	857.1	0.39%
1	Back-up Boiler	1		5000	0.25	1.00	0.0	0.00%
1	HVAC Controls	1		100	24.00	7.00	0.0	0.00%
1	Controls	1		100	24.00	7.00	0.0	0.00%
1	Phase Converter	1	250	400	24.00	7.00	6000.0	2.74%
1	L&L Kiln J18X	1	8300	8300	8.00	5.00	47428.6	21.63%

DC APPLIANCE POWER CONSUMPTION ESTIMATE

Energy Efficient Home System — Date: 3/1/2001
Home Power Magazine
St. Michaels, Arizona
Phone # — DC W.-hrs. Used Daily 2496

All appliances on the list below are DC powered directly from the batteries

No.	DC Powered Appliance	Wattage	On Time	Watt-hrs/day	%
8	Inverter idle draw (on)	13	24	2496	1.1%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%
0	0	0	0	0	0.0%

Total DC Watt-hours Consumed Daily 2496

10

Total estimated energy consumption daily-both DC and AC

219284.14 Watt-hours per day

Consumption for Unit 219284.14 Watt-hours daily

Inverter Presence? 1 1 is yes and 0 is no

Inverter surge Wattage needed 80000 Watts

Inverter priority Wattage needed 35345 Watts

Electrical Appendix

FEASIBLE BUILDING LOAD CALCULATIONS

THE CONTROL PANEL

Energy Efficient Home System — Date 3/1/2001

Home Power Magazine

St. Michaels, Arizona

Phone #

********************* THE FACTS OF THE MATTER *********************

Computer Determined Data based on User's Consumption Estimate

Consumption	219,264	Watt-hours/day	Inverter Size	44,000	Watts
Battery Voltage	24	Volts	Battery Capacity	5,950	Ampere-hours
Solar Increment	2	Panels	Optimum Solar	308	Panels
C/20 Solar	98	Panels	Stand Alone Solar	404	Panels
Solar Watts	31000	Watts	Solar Insolation	5.5	hours per day

********************* USER INPUT– THE CONTROLS *********************

Battery Storage	0.5	days	DC Generator	0	Watts
AC Generator	6500	Watts	Solar	310	Panels
			Tracker?	1	1 if true, else 0

********************* THE BOTTOM LINE *********************

Battery Storage	0.52	days	Average Storage	2.29	days
System Op Cost	$551.83	per month	Generator Time	2499	Hours/year
Leftover Power	27,980	Watts	Solar Power	101.08%	of Consumption

Initial Cost	$264,150.00	for hardware	Operating Cost	$6819.59	per year
Cost per year	$33,034.50	@10 year base	Power Cost	$0.413	per kW.-hr.
Cost per month	$2,752.88	@10 year basis			
Total Cost	$330,345.02	@10 year basis			

RENEWABLE ENERGY SYSTEM HARDWARE COST ESTIMATE for

Energy Efficient Home System — Date: 3/1/2001

Home Power Magazine

St. Michaels, Arizona

Phone # — Power Consumption 219264.14 Watt-hours/day

Initial Cost Estimate $264150.00

No.	Item Description	Type	Unit Price	Shipping @	Item Total	% of Cost
310	Siemens PV modules	SR 100	$525.00	$0.00	$162 750.00	61.61%
8	Trace Inverter	SW4024	$3,000.00	$0.00	$24 000.00	9.09%
68	Trojan Batteries	L-16	$150.00	$0.00	$10,200.00	3.86%
1	AC Generator	6500	$3,000.00	$0.00	$3,000.00	1.14%
320	Installation Labor per man-hour	estimate	$50.00	$0.00	$16,000.00	6.06%
78	PV Mounting Rack	4-SR100	$220.00	$0.00	$17,160.00	6.50%
2	Solar Boost Charge Controller	SB50	$330.00	$0.00	$660.00	0.25%
1	Wire, Conduit, Fittings	estimate	$25,000.00	$0.00	$25,000.00	9.46%
12	Battery/Inverter Fused Discon.	DC-250	$329.00	$0.00	$3,948.00	1.49%
99	Battery/Inverter Cables	estimate	$300.00	$0.00	$300.00	0.11%
1	Battery Amp-hour Meter	E-Meter	$200.00	$0.00	$200.00	0.08%
2	Fused PV Disconnect	Sq. D	$60.00	$0.00	$120.00	0.05%
8	Inverter Conduit Box	SWCB	$94.00	$0.00	$752.00	0.28%
2	DC Lightning Arrestor	Delta	$30.00	$0.00	$60.00	0.02%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%
0				$0.00	$0.00	0.00%

Total Initial Hardware Cost Estimate $264,150.00

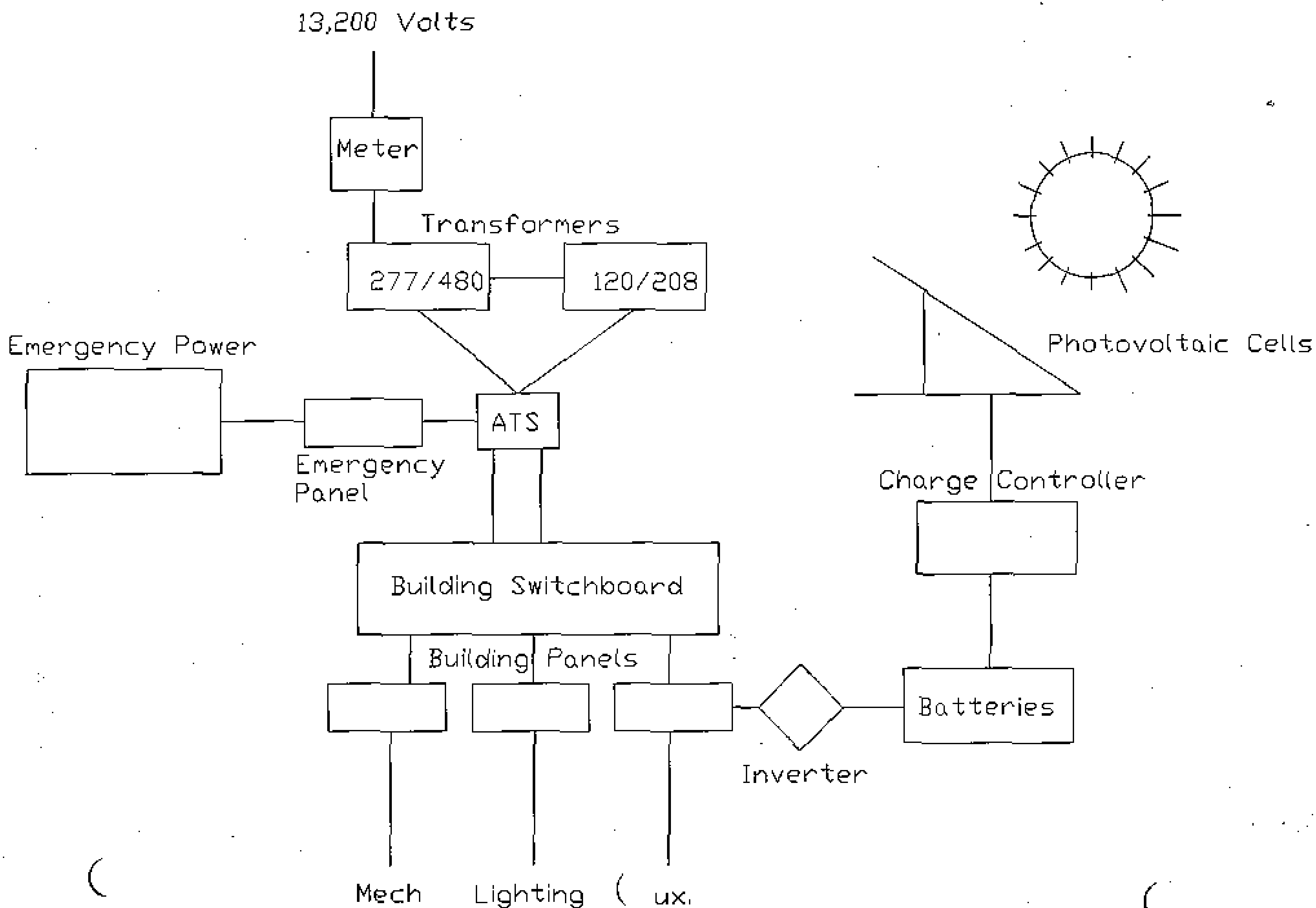
Electrical Appendix

Cost Estimate

The cost estimate is based on the hardware determined and specified on the spreadsheet. These products and any useful information can be viewable at www.solar4power.com. The following is a summary from the calculated simulation.

Initial Cost of Solar Powered System	*$264,150.00*
Estimated Cost of Overall Electrical System w/o Solar Power	*$200,000.00*
TOTAL	**$465,150.00**

The following numbers are a direct relation to the initial cost of the solar-powered system. Such as, the operating cost totaling $551.43 per month. The power cost is equal to $0.413 per kWh. Finally, an excess power wattage of 27,980 watts will be in excess.


13,200 Volts
Meter
Transformers
277/480
120/208
Emergency Power
ATS
Emergency
Panel
Photovoltaic Cells
Charge Controller
Building Switchboard
Building Panels
Batteries
Inverter
Mech
Lighting
ux.

Electrical Appendix

Lighting

Preliminary lighting calculations were made using the zonal cavity method. The specified fluorescent lamp has the following characteristics:

32 watts, T-8, 4100 K, 85 CRI, 2900 design lumens

The luminaire selected was the Simkar prismatic lens.

Room Demensions: Typical Classroom – 75' x 35'

Ceiling Height – 10'

Work Surface Height – 2.5'

RCR = [5*(CH-WSH)(L+W)]/(L*W)

= [5*(10-2.5)(75+35)]/(75*35)

= 1.57

From Simkar Lighting Catalog:

@RCR = 1, CU = 80

@RCR = 2, CU = 71

Linear Interpolation:

(2-1.57)/(2-1) = (71-CU)/(71-80)

CU = 72.9

Luminaires = (fc*area)/[(lumens/lamp)(lamps/luminaire)(CU)(LLF)]

= (75*2625)/[(2900)(4)(0.73)(.7)]

= 32.2 = 33

This calculation shows that 33 luminaires will be required in a typical classroom with a cost of $0.55 watt/SF.

Electrical Appendix

Resources/References

1. www.pvpower.com
2. www.solar4power.com
3. www.solarenergy.com
4. www.flasolar.com
5. www.eren.doe.gov/power/
6. www.seia.org
7. www.solarelectric.com
8. www.eren.gov/wind/
9. www.cogreenpower.org
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11. www.solarlighting.com
12. www.hotkilns.com
13. www.powerq.com/watt.htm
14. www.angelfire.com/nc2
15. http://www.sandia.gov/media/NewsRel/nr2000/navajos.htm
16. 1997 Simkar Lighting Catalog
17. 1998 Osram Sylvania Lamp and Ballast Catalog

Appendix G: Plumbing System Design

Water Supply

The bulk of the plumbing design begins after the architectural design is completed. The first task of the plumbing engineer is to total the building loads by summing the fixture units for each respective system; cold water supply, and hot water supply. Fixture units area tabulated by various resources and are dependent on use and type of fixture i.e. public water closet, private lavatory, private bathtub, etc. See Table 1 for fixture unit totals. The water supply line has 457 water supply fixture units, which can be broken up into 347.5 cold water fixture units and 109.5 hot water fixture units. These fixture units have an equivalent flow rate. The corresponding flow rates were in the ASPE manual. The total supply flow rate is 142 gallons per minute, 126 cold water gpm and 72.5 hot water gpm (the gpm curve is not linear see Figure 1). After the flow rates are found, the main building pipes may be sized. ASHRAE's pipe fitting (Figure 2) can be utilized to find a sufficient pipe size. This chart also shows the approximate velocity of the water in a particular pipe size and gpm. Velocity should remain between 6 and 10 ft/s to ensure flow and prevent excess noise.

Domestic Hot Water Supply

This hot water system consists of a water heater, a circulating pump, and lots of pipe. In order to size the aforementioned units three pieces of information are needed: total equivalent length of pipe, head loss in the pipe, and heat loss from the pipe.

The only way to find the total equivalent length of pipe is to lay it all out, from water heater to fixture. The total equivalent length of pipe must also be broken up by pipe size and factors added for various fittings and valves. Since the entire piping layout would be very time consuming, an estimate has been used.

Head loss in the pipe is found by multiplying the head loss factor per unit length by the total equivalent length of pipe. Head loss is dependent on material of pipe, temperature of water, length of pipe and pipe diameter. A computer program was utilized to calculate 13.5 ft of pressure head loss. See Figure 3 for details. Following the calculation of pressure head loss in the pipe total head can be calculated by adding the elevation head loss to the pressure head loss in the pipe. Elevation head is equal to the vertical distance from the deepest pipe to the highest fixture. But in a closed loop system such as ours, the elevation head does not affect the total head.

Heat loss in the pipe is found by multiplying the heat loss factor per unit length of pipe by the total equivalent length of pipe. Heat loss is also dependent on the material of the pipe and the pipe diameter. From the total heat loss the circulated hot water flow rate can be found. See Tables 2 for detailed takeoffs.

The pump size for the hot water supply can now be found. Pump manufacturers produce pump curves for each model produced. These curves are a graph of total head loss vs. flow rate. Another computer program was utilized to fit a pump curve. See figure 4 fr details. From this curve other data can be extracted including: impellor size, motor size, and pump efficiency. The pump St. Michaels will be using is an in-line centrifugal pump with ½ horsepower motor.

The water heater/storage tank may be sized by multiplying the quantity of hot water fixtures by their demand flow rate in gallons per hour. This number is multiplied by a demand factor, which is different for each type of building usage. Table 3 gives a detailed analysis of water heater/ storage tank sizing. The water heater will have a 600 gallon capacity and othe properties as in Figure 5.

Drainage System Design

The building sewer can be sized by summing the drainage fixture units for each fixture. See Table 1 for details. The building sewer can handle 201 drainage fixture units with a 4 inch pipe and ¼ inch per foot slope. See Figure 6 for details.

Another essential task of the drainage system si to prevent wastewater gases from entering the building. Drainage traps are small elbows in the drain pie immediately after the fixture, which traps inside and stops wastewater gases from escaping through the fixture. Stack vents are vertical pipes, which rise to the roof and are open to the atmosphere to prevent the gases from collecting in the drainage pipes. Figures 7 and 8 show minimum sizes of traps and stack vents, respectively.

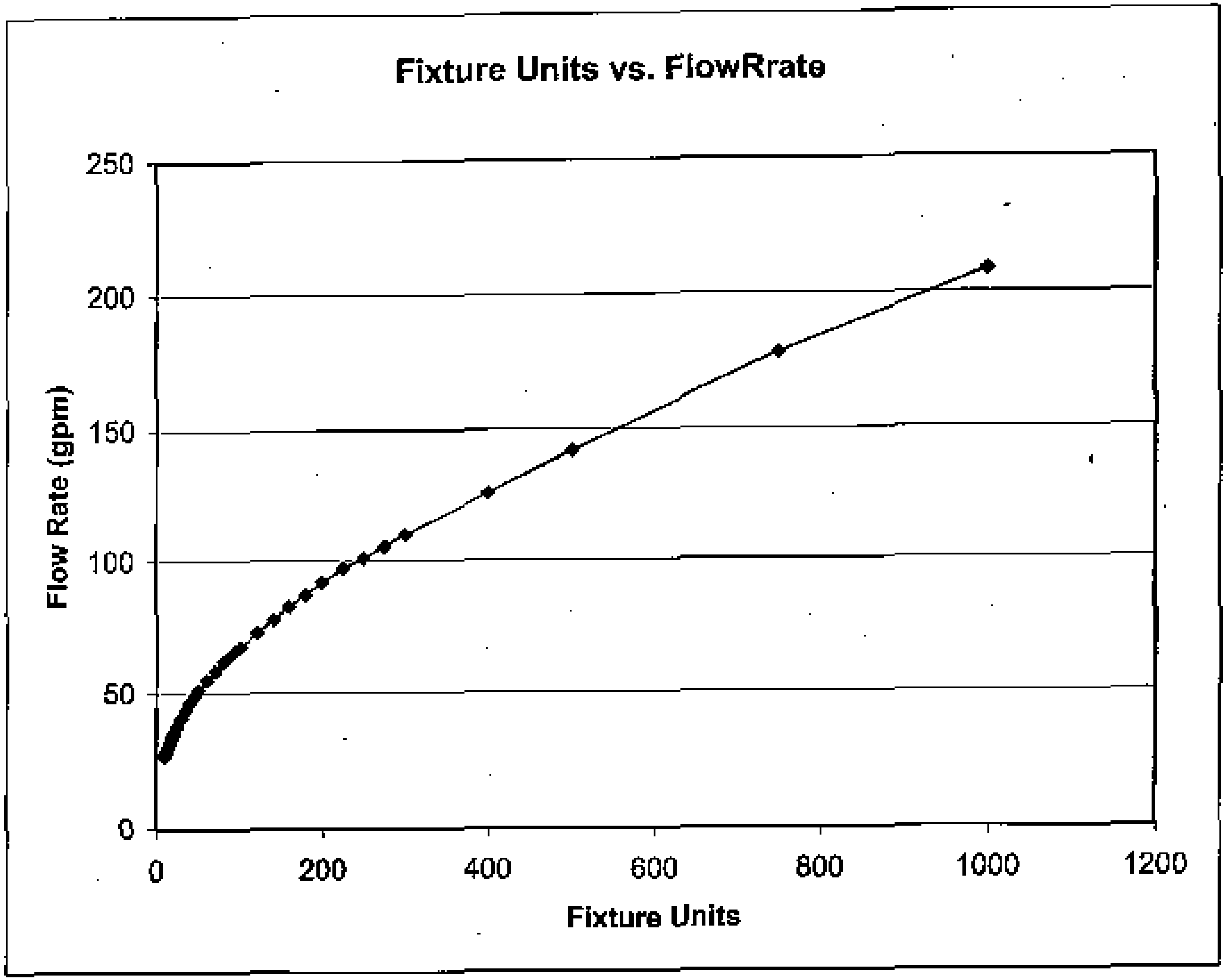
Table 1: Water Supply and Drainage System

Quantity	Fixture	Drainage Fixture Units	Total	Cold Water Fixture Units	Total	Hot Water Fixture Units	Total
22	Water Closet Flush Valve	4	88	10	220		
20	Lavatory	1	20	1.5	30	1.5	30
2	Service Sink	2	4	2.25	4.5	2.25	4.5
2	Shower	3	6	3	6	3	6
14	Tub	3	42	3	42	3	42
3	Washing Machine	2	6	3	9	3	9
4	Floor Drains	4	16				
5	Kitchen Sink	3	15	3	15	3	15
1	Dish Washer	4	4	3	3	3	3

Totals							
Cold Water FV	329.5						
Non-flush Valve	18						
Total Cold Water Fixture Units	347.5	=	126 gpm	=	3" pipe	=	6.25 fps
Hot Water	109.5	=	72.5 gpm	=	2.5" pipe	=	7.5 fps
Total Water Supply Fixture Units	457	=	142 gpm	=	3" pipe	=	7 fps
Total Drainage Fixture Units	201	=	4" pipe	=	1/4" per foot slope		

Figure 1

Fixture Units	GPM
10	27
12	28.6
14	30.2
16	31.8
18	33.4
20	35
25	38
30	41
35	43.8
40	46.5
45	49
50	51.5
60	55
70	58.5
80	62
90	64.8
100	67.5
120	72.5
140	77.5
160	82.5
180	87
200	91.5
225	97
250	101
275	105.5
300	110
400	126
500	142
750	178
1000	208



**extracted from the ASPE Data Book Volume 4 Chapter 1 Plumbing Fixtures

Figure 2

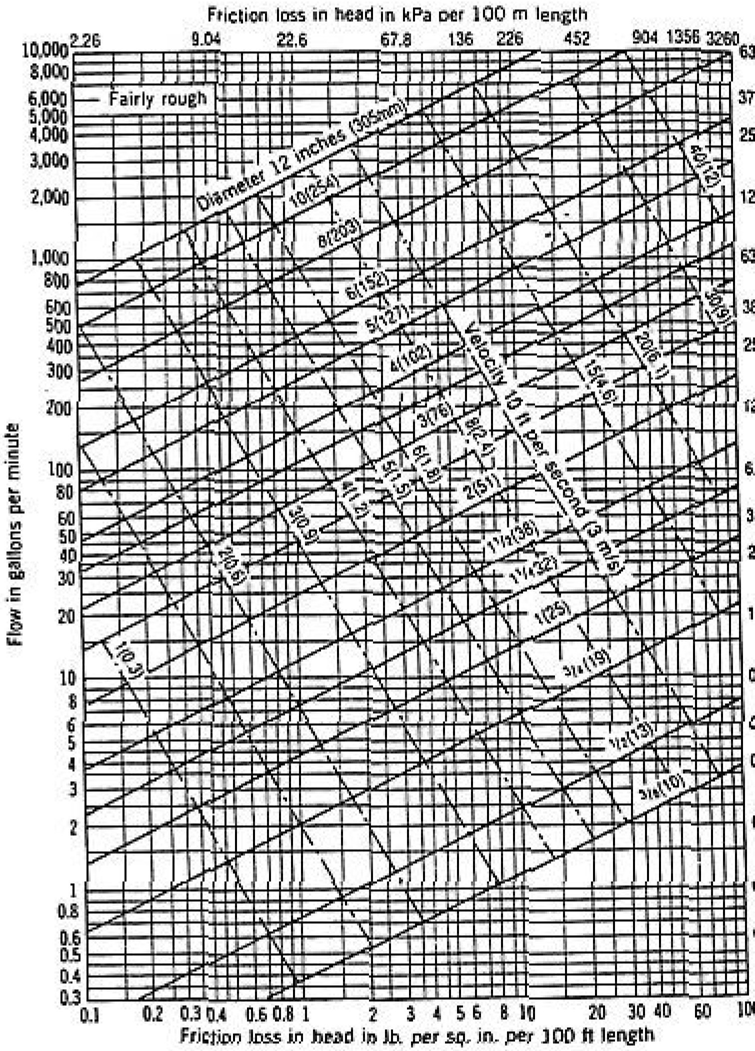


Fig. 9.49 Flowchart for typical (fairly rough) pipe. Velocity is shown, as an aid in noise control: above 10 fps (3m/s), moving water can be heard within pipes. (Copyright © by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, Ga. Adapted by permission from ASHRAE Handbook of Fundamentals, *1972.)*

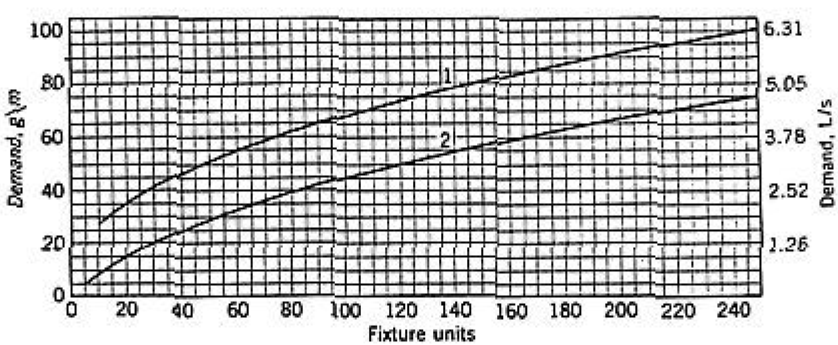


Fig. 9.50 Estimate curves for demand load. Curve 1 is for a system of predominantly flush valv Curve 2 is for a system of predominantly flush tanks. (Copyright © by the American Society Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, Ga. Adapted by permiss from ASHRAE Handbook of Fundamentals, *1989.)*

Figure 3

The Free Engineering Software Website

CGI PERL Scripts

Home | Scripts | Download | Advertise | Contact | Links

The Fluid Flow Calculator

This is your input:	These are the results:
fluid: 0 % solution	velocity ft per second: 1.5555
fluid temp F: 120F	Reynold's Number: 40739.5761
flow rate GPM: 15	friction factor fa: 0.0216
pipe size in: 2	friction factor f: 0.0220
pipe length ft: 2700	head loss ft: 13.5073
pipe material: C	pressure loss psi: 5.7946

flow calculator developed by Michael J. Rocchetti PE
Back to the Calculator

http://www.connel.com/cgi-bin/flowcalc1.pl

Table 2

Burt Hill
Kosar Rittelmann
Associates

JOB TITLE:						
JOB NO.	SUBJECT	BY:	DATE:	CHK'D	DATE	PAGE OF
	Sizing Domestic H.W. Recirc.					

PIPE SIZE	TOTAL HWS & HWR LINEAL FEET	BTU/HR/LIN.FT	LINEAL FT X BTU = HEAT LOSS
½"		15	
¾"		17	
1"	675	19	12 825
1 ¼"		21	
1 ½"		25	
2"	1350	28	37800
2 ½"		32	
3"	675	38	25650
4"		46	
5"		55	
6"		63	

TOTAL 76275
Divided by 5,000
= 15.25 GPM
TO BE RECIRCULATED

INITIALLY USE ¾" FOR RECIRC SIZE. IF, AFTER CALCULATIONS ARE COMPLETE, VELOCITY AND PRESSURE DROP OF GPM IN A ¾" PIPE ARE IN EXCESS, INCREASE ¾" RECIRC LINE TO 1".

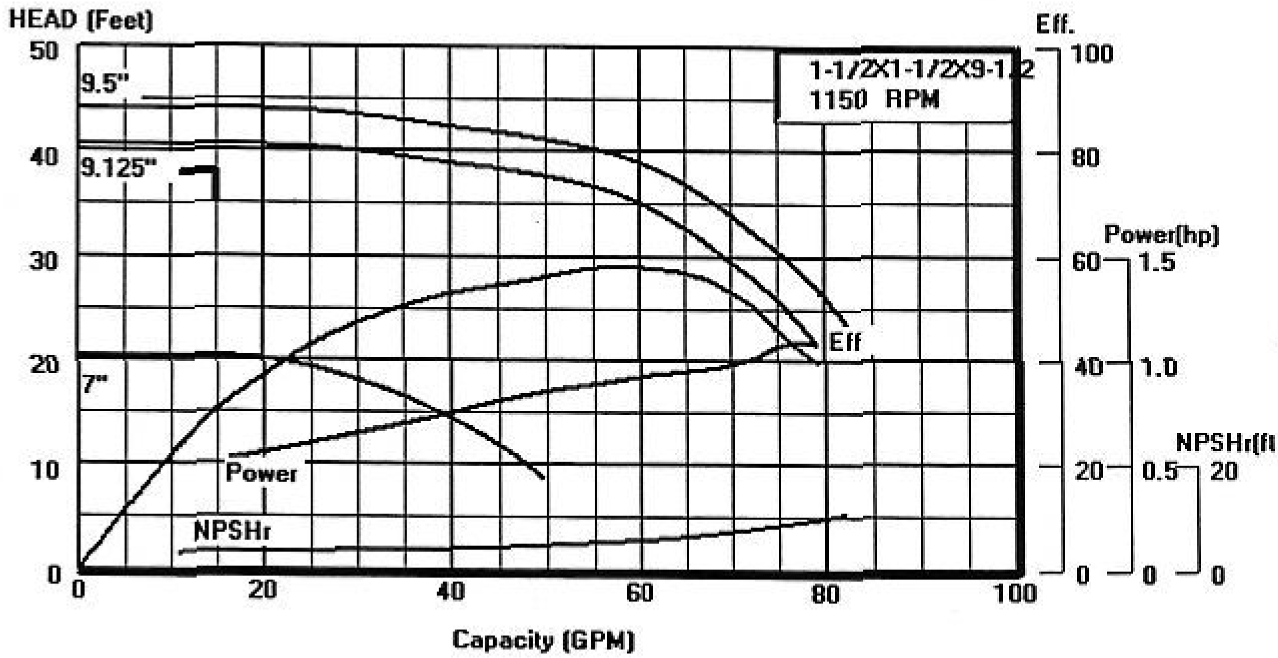
take off list provided by Joe Smaul P.E. BHKR Associates.

Figure 4

Bell & Gossett

ITT Industries

Curve Generation
Version C1.16



Pump Series: 80
Suction Size = 1.5 "
Discharge Size = 1.5 "

Min Imp Dia = 7 "
Max Imp Dia = 9.5 "
Cut Dia = 9.125 "

Design Capacity =15.0
Design Head =30.0
Motor Size =.5 HP

ITT Bell & Gossett
8200 N. Austin
Morton Grove, Il 60053

The Power and Eff. curves shown are for the cut dia. impeller.

http://appserver.ittind.com/software/plus/ESPinscreen.htm

Table 3: Storage Tank Sizing

School

Quantity	Fixture	gal / hr	Total
20	Lavatory	15	300
2	Shower	225	450
14	Tub	20	280
5	Kitchen Sink	10	50
1	Dish Washer	100	100
3	Washing Machine	100	300
		Total Demand	1480

school demand factor	0.4
storage capacity	1

Optimum Storage Size = Total Demand * Demand Factor * storage capacity

Optimum Storage Size = 592 gal / hr

Figure 5

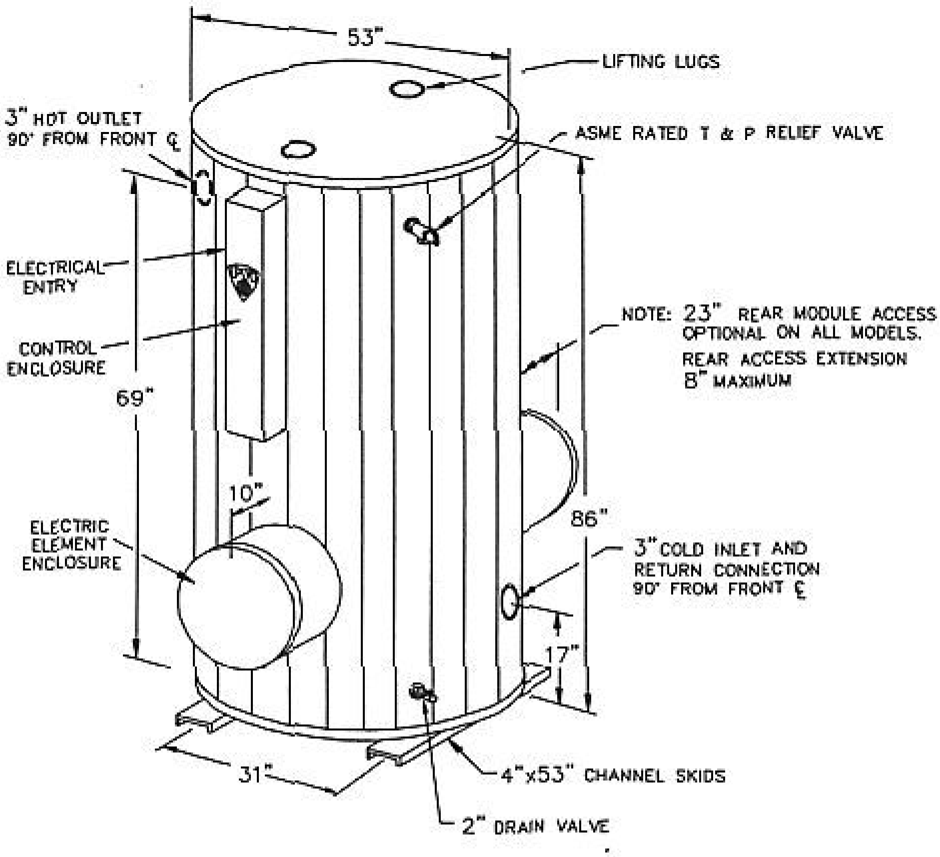
DURAWATT® ELECTRIC • PACKAGED WATER HEATER

NICKELSHIELD® NICKEL-PLATED STORAGE TANK

TANK SERIES 600 GALLONS

MODEL NUMBER	RECOVERY RATE GPH		INPUT kW	NUMBER OF ELEMENTS		ELEMENT AMPS					SHIPPING WEIGHT
	40°-120°F	40°-140°F		80 W/IN²	40 W/IN²	208V, 1Ø	240V, 1Ø	208V, 3Ø	240V, 3Ø	480V, 3Ø	
90 N 600A-E	90	70	18	1	2	87	75	50	44	22	2120 #
180 N 600A-E	180	150	36	2	4	174	150	100	87	44	2120 #
270 N 600A-E	270	220	54	3	6	260	225	150	130	65	2130 #
370 N 600A-E	370	300	72	4	8	347	300	200	174	87	2130 #
460 N 600A-E	460	370	90	5	10	433	375	250	217	109	2140 #
550 N 600A-E	550	440	108	6	12	520	450	300	260	130	2160 #
650 N 600A-E	650	520	126	7	14	606	525	350	304	152	2170 #
740 N 600A-E	740	590	144	8	16	693	600	400	347	174	2190 #
920 N 600A-E	920	740	180	10	20	866	750	500	434	217	2220 #
1100 N 600A-E	1100	880	216	12	[redacted]	1039	900	600	520	260	2230 #
1300 N 600A-E	1300	1030	252	14	[redacted]	1212	1050	700	607	304	2240 #
1470 N 600A-E	1470	1180	288	16	[redacted]	1385	1200	800	693	347	2250 #
1600 N 600A-E	1600	1330	324	18	[redacted]	1558	1350	900	780	390	2260 #
1850 N 600A-E	1850	1480	360	20	[redacted]	1731	1500	1000	867	434	2270 #

FOR STANDARD AND OPTIONAL EQUIPMENT, SEE FORM #PV 6008.
ASHRAE 90.1 COMPLIANT



CONTROL CIRCUIT TRANSFORMER SUPPLIED ON 480V ONLY. TAPPED CONTROL CIRCUIT INTERNALLY WIRED FOR 208V AND 240V. 208V AND 240V MODELS REQUIRE AC NEUTRAL CONDUCTOR FOR GROUNDING OF CONTROL CIRCUIT.

ALTERNATE VOLTAGES: FOR 230/460V, MULTIPLY kW AND RECOVERY BY .92. MULTIPLY AMPS BY .96.
FOR 220/440V, MULTIPLY kW AND RECOVERY BY .84. MULTIPLY AMPS BY .92.

PVI RESERVES THE RIGHT TO CHANGE THE DESIGN AND SPECIFICATION WITHOUT NOTICE.

U.S. Patents: 4,869,208; 4,968,066
Canadian Patents: 1,286,932; 2,007,302
Mexican Patent:: 167,200

PV 5586 11/98

PVI INDUSTRIES, INC.
FORT WORTH, TEXAS 76111
(800) 784-8326

Figure 6

TABLE 10.10 **Building Drains and Sewers**[a]

Diameter of Pipe (in.)	(mm)	Maximum Number of Fixture Units That May Be Connected to Any Portion of the Building Drain or the Building Sewer Including Drain Branches — Fall per Foot (mm per m): 1/16 in. (5.2)	1/8 in. (10.4)	1/4 in. (20.9)	1/2 in. (41.7)
2	51			21	26
2½	64			24	31
3	76		36[b]	42[b]	50[b]
4	102		180	216	250
5	127		390	480	575
6	152		700	840	1,000
8	203	1,400	1,600	1,920	2,300
10	254	2,500	2,900	3,500	4,200
12	305	2,900	4,600	5,600	6,700
15	381	7,000	8,300	10,000	12,000

Source: National Standard Plumbing Code. (*Metric conversions by author.*)

[a]On-site sewers that serve more than one building may be sized according to the current standards and specifications of the Administrative Authority for public sewers.

[b]Not more than two water closets or two bathroom groups.

TABLE 10.11 **Horizontal Fixture Branches and Stacks**

Diameter of Pipe (in.)	(mm)	Maximum Number of Fixture Units that May Be Connected to: Any Horizontal Fixture Branch[a]	Stack Sizing for 3 Stories in Height or 3 Intervals	Stack Sizing for More than 3 Stories in Height: Total for Stack	Stack Sizing for More than 3 Stories in Height: Total at 1 Story or 1 Branch Interval
1½	38	3	4	8	2
2	51	6	10	24	6
2½	64	12	20	42	9
3	76	20[b]	48[b]	72[b]	20[b]
4	102	160	240	500	90
5	127	360	540	1,100	200
6	152	620	960	1,900	350
8	203	1,400	2,200	3,600	600
10	254	2,500	3,800	5,600	1,000
12	305	3,900	6,000	8,400	1,500
15	381	7,000			

NOTE: Stacks shall be sized according to the total accumulated connected load at each story or branch interval and may be reduced in size as this load decreases to a minimum diameter of ½ of the largest size required.

Source: National Standard Plumbing Code. (*Metric conversions by author.*)

[a]Does not include branches of the building drain.

[b]Not more than two water closets or bathroom groups within each branch interval or more than six water closets or bathroom groups on the stack.

Figure 7

TABLE 10.8 **Size of Nonintegral Traps for Different-Type Plumbing Fixtures**

Plumbing Fixture	*Trap Size in Inches*	*Trap Size (mm)*
Bathtub (with or without overhead shower)	1½	38
Bidet	1¼	32
Combination sink and wash (laundry) tray	1½	38
Combination sink and wash (laundry) tray with food waste grinder unit	1½[a]	38[a]
Combination kitchen sink, domestic, dishwasher, and food waste grinder	2	51
Dental unit or cuspidor	1¼	32
Dental lavatory	1¼	32
Drinking fountain	1¼	32
Dishwasher, commercial	2	51
Dishwasher, domestic (nonintegral trap)	1½	38
Floor drain	2	51
Food waste grinder—commercial use	2	51
Food waste grinder—domestic use	1½	38
Kitchen sink, domestic, with food waste grinder unit	1½	38
Kitchen sink, domestic	1½	38
Kitchen sink, domestic, with dishwasher	1½	38
Lavatory, common	1¼	32
Lavatory (barber shop, beauty parlor or surgeon's)	1½	38
Lavatory, multiple type (wash fountain or wash sink)	1½	38
Laundry tray (1 or 2 compartments)	1½	38
Shower stall or drain	2	51
Sink (surgeon's)	1½	38
Sink (flushing rim type, flush valve supplied)	3	76
Sink (service type with floor outlet trap standard)	3	76
Sink (service trap with P trap)	2	51
Sink, commercial (pot, scullery, or similar type)	2	51
Sink, commercial (with food grinder unit)	2	51

Source: National Standard Plumbing Code. (*Metric conversions by author.*)

[a]Separate traps required for wash tray for sink compartment with food waste grinder unit.

fixtures) instead of coping with the pressures and suctions that normal effluent would cause (see Figs. 10.48 and 10.49).

The "plunger" effect of a descending "slug" of water/waste within pipes was described in Section 10.3. If the effectiveness of the "plunger" can be reduced, the negative and positive pressures created by it will be also reduced. If their values can be brought down below the holding power of the several inches of water in the trap, no vents will be necessary. In the single-stack *Sovent* system illustrated in Fig. 10.49, this is done by dealing with the normal liquid effluent at each floor. Aeration there produces a *foam* that lacks the stack-filling tendency of the liquid effluent. Thus, through the creation of a *soft* plunger, pressure variations in the single stack are minimized.

Tests have shown that the positive and negative pressures produced by *normal* liquid effluent during its descent and relieved by the vent piping are often about 5 to 12 in. (127 to 305 mm) water gauge. Obviously, if the vents were not provided, the 2 to 4 in. (51 to 102 mm) of water seal in the traps would be vulnerable to penetration by gases from pipes under positive pressure or siphonage of water seals into pipes that may be under negative pressure.

Figure 8

TABLE 10.12 **Size and Length of Vents**
Part A, Conventional Units

Size of Soil or Waste Stack	Fixture Units Connected	Diameter of Vent Required (in.)								
		1¼	1½	2	2½	3	4	5	6	8
		Maximum Length of Vent (ft)								
Inches										
1½	8	50	150							
1½	10	30	100							
2	12	30	75	200						
2	20	26	50	150						
2½	42		30	100	300					
3	10		30	100	200	600				
3	30			60	100	500				
3	60			50	80	400				
4	100			35	100	260	1000			
4	200			30	90	250	900			
4	500			20	70	180	700			
5	200				35	80	350	1000		
5	500				30	70	300	900		
5	1100				20	50	200	700		
6	350				25	50	200	400	1300	
6	620				15	30	125	300	1100	
6	960					24	100	250	1000	
6	1900					20	70	200	700	
8	600						50	150	500	1300
8	1400						40	100	400	1200
8	2200						30	80	350	1100
8	3600						25	60	250	800
10	1000							75	125	1000
10	2500							50	100	500
10	3800							30	80	350
10	5600							25	60	250

Source: National Standard Plumbing Code.

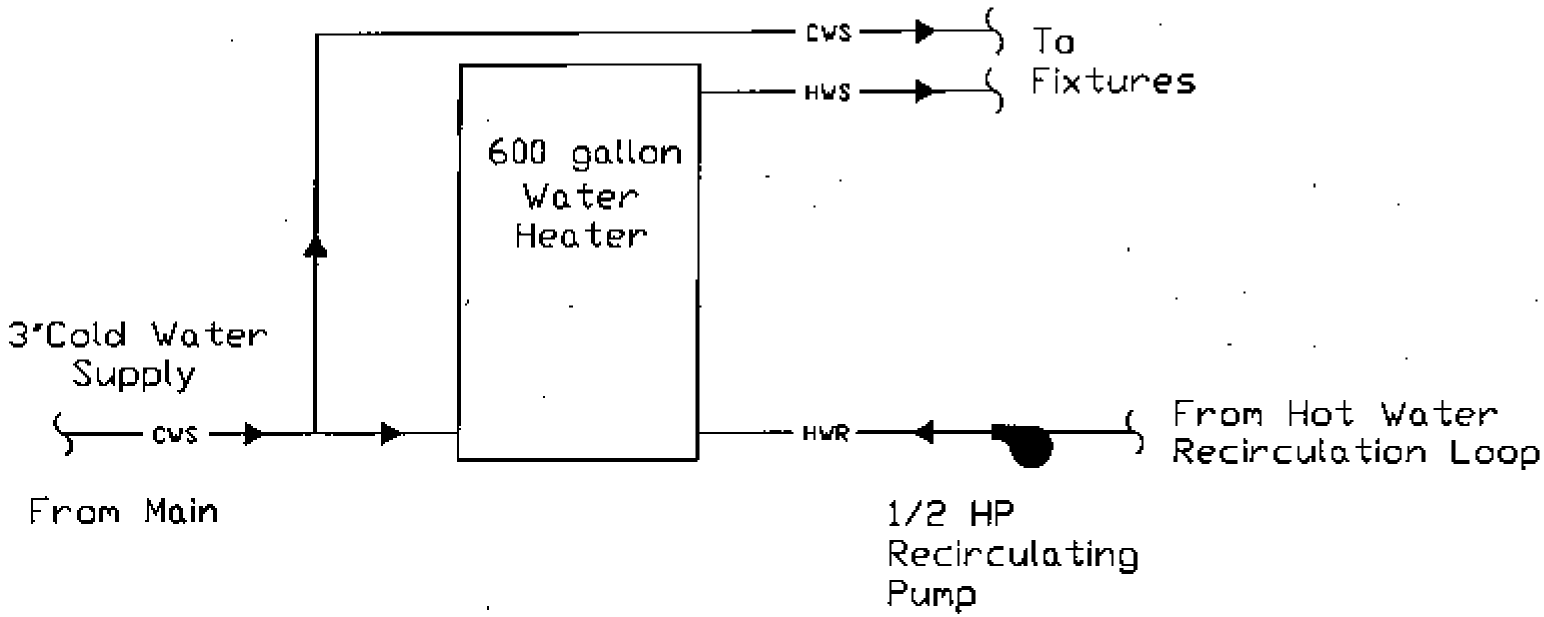
WATER AND WASTE

...gures 10.48, 10.49, and 10.50 illustrate the ...ponents and the action of the Sovent sys-... Effluent, already aerated and descending ...upper stories, is diverted in the stack at ...lower story. The aerator fitting there af-...a passage for this diverted flow and also an ...pace into which the effluent from the local ...h soil or waste can drop. Here it spatters, ...g with the air to form a rarified mixture of ...d liquid. Tests show that this mixture does ...roduce pressures, positive or negative, of ...than 1 in. (25 mm) water gauge. Thus a ...eal of 2 in. (51 mm) or more is safe against ...page or penetration.

...the foot of the single stack the aerated effluent is compacted—a process aided by a baffle in the path of the flow in the deaerator fitting (see Fig. 10.50). If not relieved, air piling up at this point could cause pressures in the stack at the first floor. An air-discharge pipe provides this relief of air from the deaerator fitting to the upper part of the building drain, above the liquid flow.

The Sovent system was invented by Fritz Sommer of Switzerland, who tested it in a 10-story drainage test tower. Since its introduction in 1962, it has been installed and used in hundreds of buildings in Europe and Africa. Canada used the Sovent method in the Habitat apartments at the 1967 Montreal expo. Sovent was

Figure 9: Single Line Diagram



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1. Joe Smaul P.E. Burt Hill Kosar Rittleman Associates

2. Stein and Reynolds, *Mechanical and Electrical Equipment for Buildings*, John Wiley and Sons, 1992.

3. The BOCA National Plumbing Code 1993

4. ASPE Data Book Volume 4

5. ASHRAE Fundamentals 1993

6. http://appserver.ittind.com/software/plus/ESPinscreen.htm

7. http://www.connel.com/cgi-bin/flowcalc1.pl

8. http://www.pvi.com/waterheaters.htm

ECONOMIC ANALYSIS

System Cost Breakdown

➲Site Development	$65,000
➲Geotechnical	$246,000
➲Architectural	$2,300,000
➲Structural	$1,000,000
➲HVAC	$936,000
➲Electrical	$465,000
➲Plumbing	$147,000
➲Contingency	$975,000
➲Design Fee	$750,000
➲Total	$6.8 Million

2000/2001 SCHEDULE