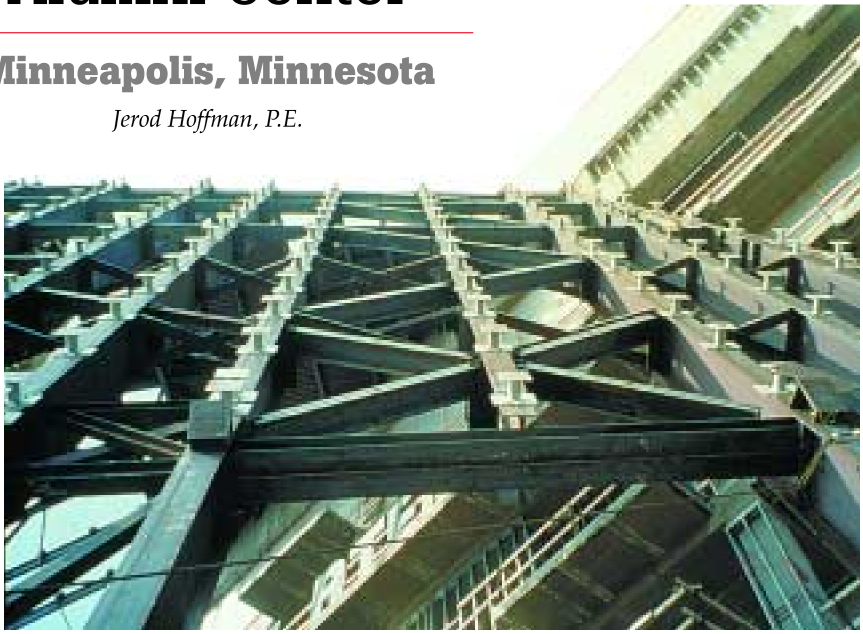
NATIONAL WINNER

ENGINEERING
Awards of Excellence

MCNAMARA Alumni Center

Minneapolis, Minnesota

Jerod Hoffman, P.E.

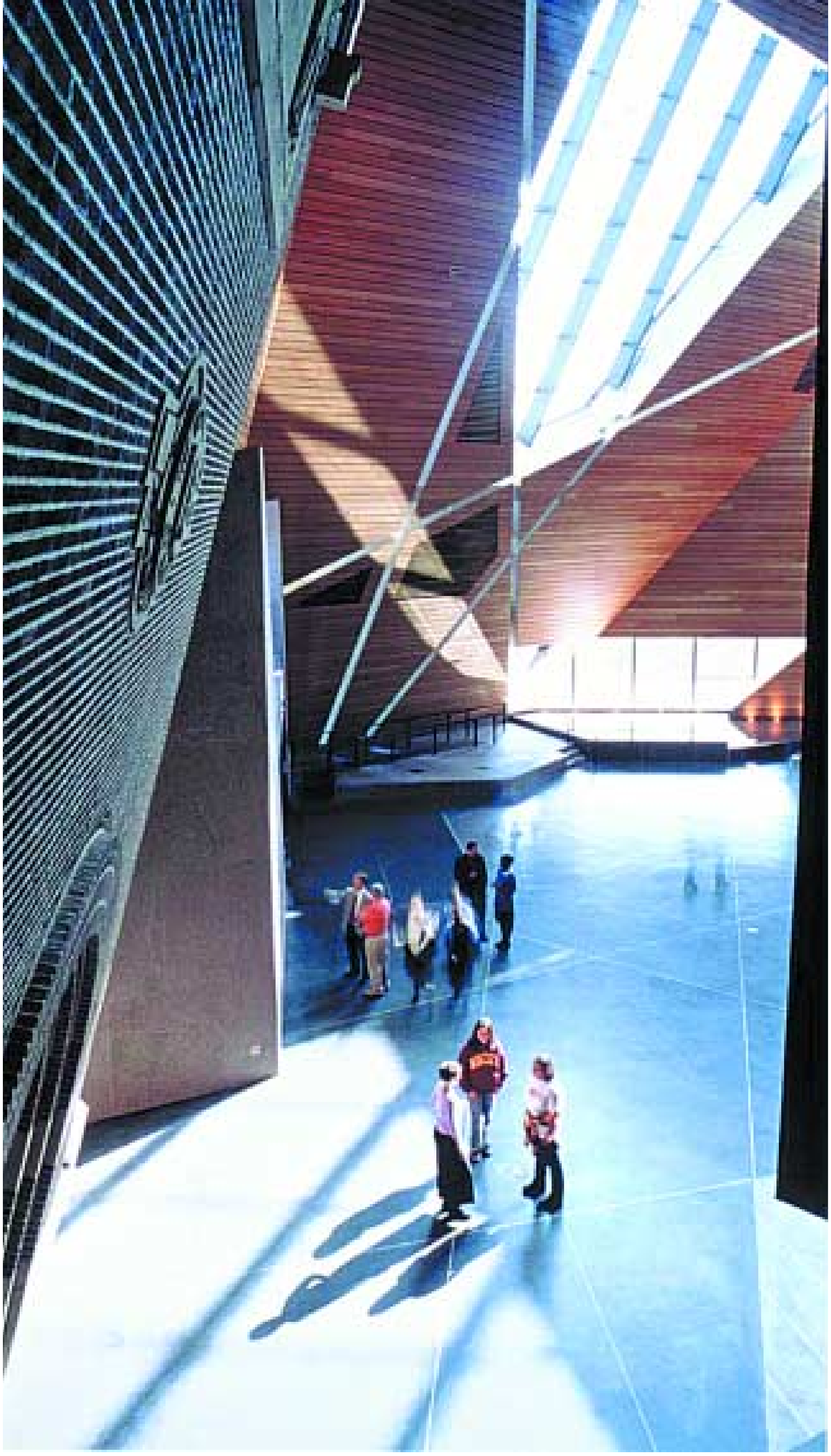


In 1957, the University of Minnesota Alumni Association first expressed a need for an alumni and visitor center for the campus. Throughout the next 43 years, this agenda item took on a life of its own. With the numerous University requirements and red tape, it was an uphill battle. The determination of three alumni and the generous donations of many other former students kept the momentum going for this very important building project. What started as a need for an alumni center grew into a multifunctional building that would serve the entire university. At 40,000 students, the University of Minnesota needed a focal point for prospective and current students, staff and alumni. With the selection of world-renowned architect Antoine Predock, the McNamara Alumni Center would become known not only for the importance of the people it serves but also as the monumental building on campus with a bold geometric form.

The 230,000 sq. ft. building consists of two portions; a seven-story rectangular office block clad in copper and a 90′ tall multi-surface "geode", which houses the public spaces. The Geode portion of the project is what makes this building unique. The Geode is a rock-like structure clad in granite, faceted and sliced with windows, or fissures, that crisscross in random patterns. Predock is known for his bold forms that resemble the landscape around them, as well as capturing the spirit and meaning of the building's use. He drew inspiration from the Split Rock geologic form on the North Shore of Minnesota. Also, the light that streams out the many irregular windows at night resembles a beacon drawing people to this campus focal point. The inside of the Geode includes Memorial Hall, which is a 90′ tall open atrium, Heritage Gallery and the reconstructed Memorial Arch.

Entrant's Role in the Project

Meyer, Borgman and Johnson (MBJ) was the structural engineer of record for this project, responsible for all structural related design, analysis and document preparation from the foundation to the roof. MBJ's scope included the rectangular office portion, the Geode and the primary support



structure for the Memorial Arch. The office portion utilized cast-in-place post-tensioned concrete framing. The Geode portion included primary structural steel framing and a secondary steel framing system for supporting the granite.

MBJ provided essential coordination services throughout the design phase of the project, especially for the intricate relationships between the granite, windows, structural steel and roofing materials for the Geode. In addition, MBJ was responsible for construction phase services, including shop drawing review, construction coordination meetings and site inspections.

Original or Innovative Engineering Techniques

Several areas of this project required original and innovative work by MBJ. The complex geometry of the Geode posed a difficult problem for modeling and analyzing the structural steel frame that would create the exterior envelope of the building. There were 17 different surfaces, all sloping at various angles. It was immediately evident that the project would require a sophisticated computer model to set-up, manipulate and analyze the work points of the steel-framing members. MBJ's innovative approach to this challenge started by using AutoCAD to convert the architect's top of granite surfaces to top of steel surfaces, typically a 1′-4″ offset. Work points were created and the steel beams were laid out on each surface, identified by line segments. Each surface had it's own CADD drawing that referenced the same base model, which greatly facilitated updating framing layouts and preparing the construction documents. Once complete, this 3D-wire frame model was imported into a structural analysis computer program. This process eliminated the traditional step of hand input of dimensional coordinates for each beam of the structure, which was not feasible for the Geode. In addition, the top of steel CADD model was shared with the steel detailer for infinite precision in work points.

A second innovative approach by MBJ involved the development of steel connections. Again, the complexity of the framing required a different approach compared to typical steel-framed buildings. The following process was used to transfer the connection data and optimize the connection design:

MBJ detailed general connection relationships for all conditions. Many of the steel member sizes and shapes designed by MBJ were chosen based on the connection geometry;

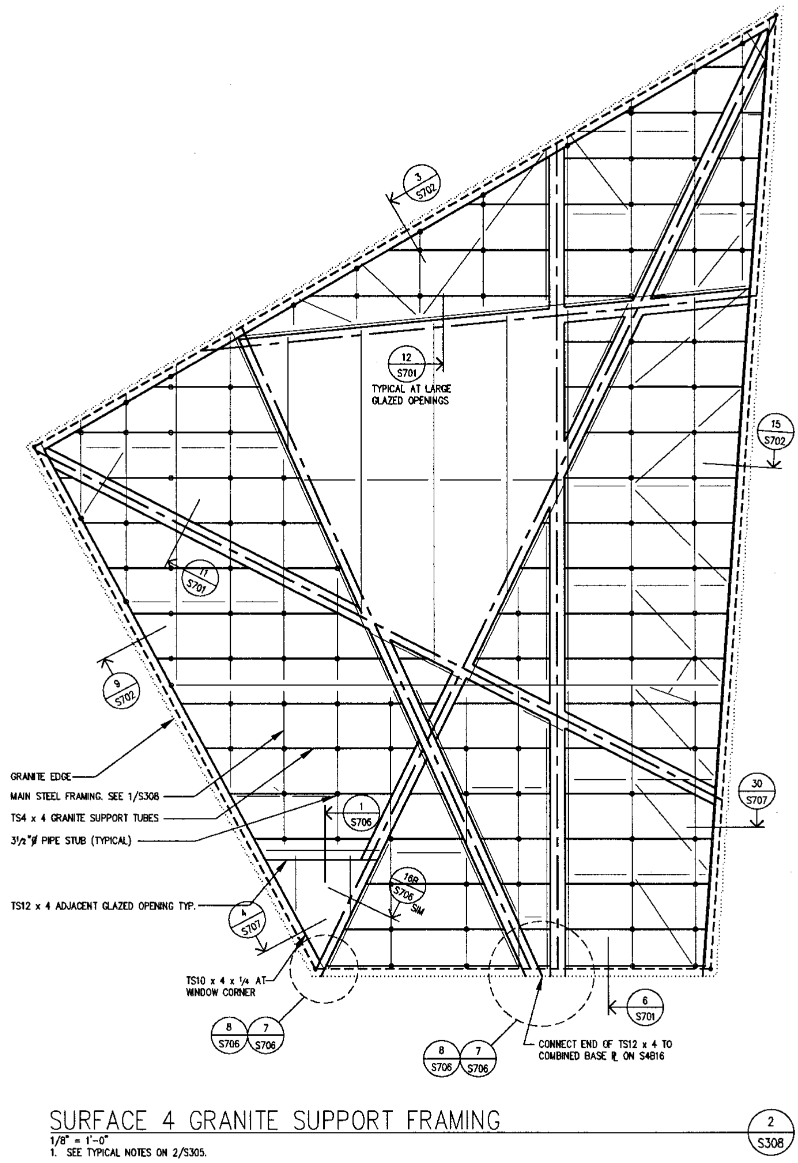
Load data at the connections for each steel beam was extracted from the structural design program, organized in spreadsheet format and included as part of the structural documents. Many load combinations were studied to determine the most critical conditions. This load data had up to six times the amount of information that is typically provided to the steel fabricator;

Connection optimization and economy was achieved by collaborating with the steel fabricator, and reviewing, editing and approving their connection geometry and recommendations.

MBJ also developed a unique secondary steel structure that provided support for the granite façade of the Geode. This thermally exposed system had to accommodate the cyclic expansion and contraction of the steel. The solution consisted of galvanized 4″ x 4″ steel tubes, spaced at 5′ on center, and galvanized steel stub columns connected to the primary steel structure (see Figure 2). This system was detailed so that the bolted connections allow infinite movement cycles without damaging the steel, granite or any surrounding materials. The coefficients of friction and magnitudes of loads from these temperature movements were determined, and then maximum bolt tightening values were specified.

The unique geometry and load paths of the Geode placed unusual demands on the adjacent concrete framed office building. A lateral force applied to the seventh floor of the building from the Geode had a magnitude of 280,000 lbs., due to the self-weight and applied snow load on the Geode. Compared to the wind load on the building in this direction, this force is equivalent to adding six stories to the building, which greatly increases the requirements for the lateral load resisting system. MBJ utilized massive concrete shear walls, unique post-tensioned outrigger beams and driven steel pipe piles to bedrock to resist these forces.

The phased loading during construction required separate analysis from the completed structure. MBJ realized that if temporary slide-bearing connections were used in a few key areas during construction that the amount of force transferred at these areas could be substantially reduced. This innovative approach was cost effective.



Technical Value to the Engineering Profession

This structure provides at least four areas of technical value to the engineering profession. First, it provides an example of how connection design may be effectively developed and economized for the most complex and irregular steel framed structures. The expanded breadth of information sharing and collaboration with the steel fabricator produces more appropriate and cost-effective solutions for these conditions.

Second, MBJ's efforts provide a solution for supporting thin granite veneer on sloped steel framed structures with large surface areas, complex geometry and/or random window openings. The solution exhibits several qualities, including the flexibility to be applied to many geometric conditions, ease of erection including allowance for construction tolerances and adequate space for insulation and waterproofing. Also, it accommodates critical thermal movements.

Third, this building models the potential for integrating concrete and steel framing systems for efficient cost-effective design solutions. Each system was chosen to best accommodate the framing requirements imposed.

Fourth, this project provides insight into the use of temporary slide-bearing connections during the construction phase to reduce load requirements.

Social and Economic Considerations

The public's appreciation of this structural challenge makes it an important landmark for those on campus and also a draw to perspective students. During the design phase, the building was known as the Gateway Center, located at the edge of campus and symbolized by the original Memorial Stadium Processional Arch. The arch was reconstructed within the new Memorial Hall (leaning inward at 15 degrees). The original brick and stone were salvaged from the recently demolished Memorial Football Stadium and rebuilt to create this 30′ x 50′, 70-ton arch. Once you walk through the arch, you enter Heritage Gallery, which preserves and displays artifacts and innovations of the University of Minnesota's 150-year tradition. Heritage Gallery and the rebuilding of Memorial Arch provide alumni and society with many social benefits. World War I veterans are honored with the inscription on the arch, and the memories of football players and fans are brought to life.

One direct social and economic benefit of the 90′ tall Memorial Hall is that it provides a spectacular place to hold important public and University of Minnesota events such as speaking engagements, homecoming events and graduation and award ceremonies. The building structure is central to the grand appeal of this public space, and its position as the "gateway" to the University of Minnesota campus. Now in use, the public spaces of this building are booked with an average of 15 events every week.

This bold and controversial architecture provides for several economic benefits to the campus. It helps attract highly qualified students and professors, which raises the standard and reputation of the University. This unique building appeals to groups for highly publicized events and gatherings, and it symbolizes the forward, contemporary risk-taking thinking of University leadership.

Complexity

Complexity is the single greatest theme illustrated by this project. In addition to the 3D, rock-like formation, the structural steel had to conform geometrically to other architectural constraints. The skewed, non-orthogonal layout of slit and large windows greatly increased the complexity of steel framing. No primary steel greater than 36″ deep was allowed, which was a challenge with surface spans up to 100′. Almost all other buildings with large sloped surfaces have floors and columns to back-up the surface, which makes the framing routine. This project was lacking those elements, making these spans and geometry extremely difficult to structure.

The project requirements for design and construction timetable were extremely aggressive for a building of this size and complexity. Multiple bid packages were utilized to provide for the fast-track schedule. Coordination with the team consultants and contractors occurred on a weekly basis, where MBJ lead many of the coordination issues for the Geode. Special care for designing and detailing steel framing for constructibility and tolerances was vital to efficiency. Strategies included oversize holes with special tightening requirements, bolted connections whenever practical and minimizing the amount of welding.

Many of the analysis, design and detailing aspects for this project can easily be considered out-of-the-ordinary, including:

Complex 3D Computer model: The large geometric model, which included approximately 1,000 joints and 1,700 beam segments, was unique due to its lack of redundancy and extent of the sloping and skewed members. The complexity of this model certainly outshadows that of either a large sports arena or high-rise building, which often have a lot of redundancy and limited skewed framing. The time required to completely create, refine and analyze the Geode frame was approximately 800 hours (4 to 5 months). This is magnitudes beyond what is typically spent modeling framing systems for mid-rise buildings.

Structural analysis: The overall system load path was very complex and impossible to determine without a robust 3D digital model. The system wind loads were evaluated in six directions, due to the irregular building shape. Typical member deflection limits did not apply. New deflection limits needed to be established (limited to two to four times less than typical structures) based on the granite system flexibility and sequential granite placement. In-plane steel bracing elements were strategically placed to ensure stability and overall frame rigidity.

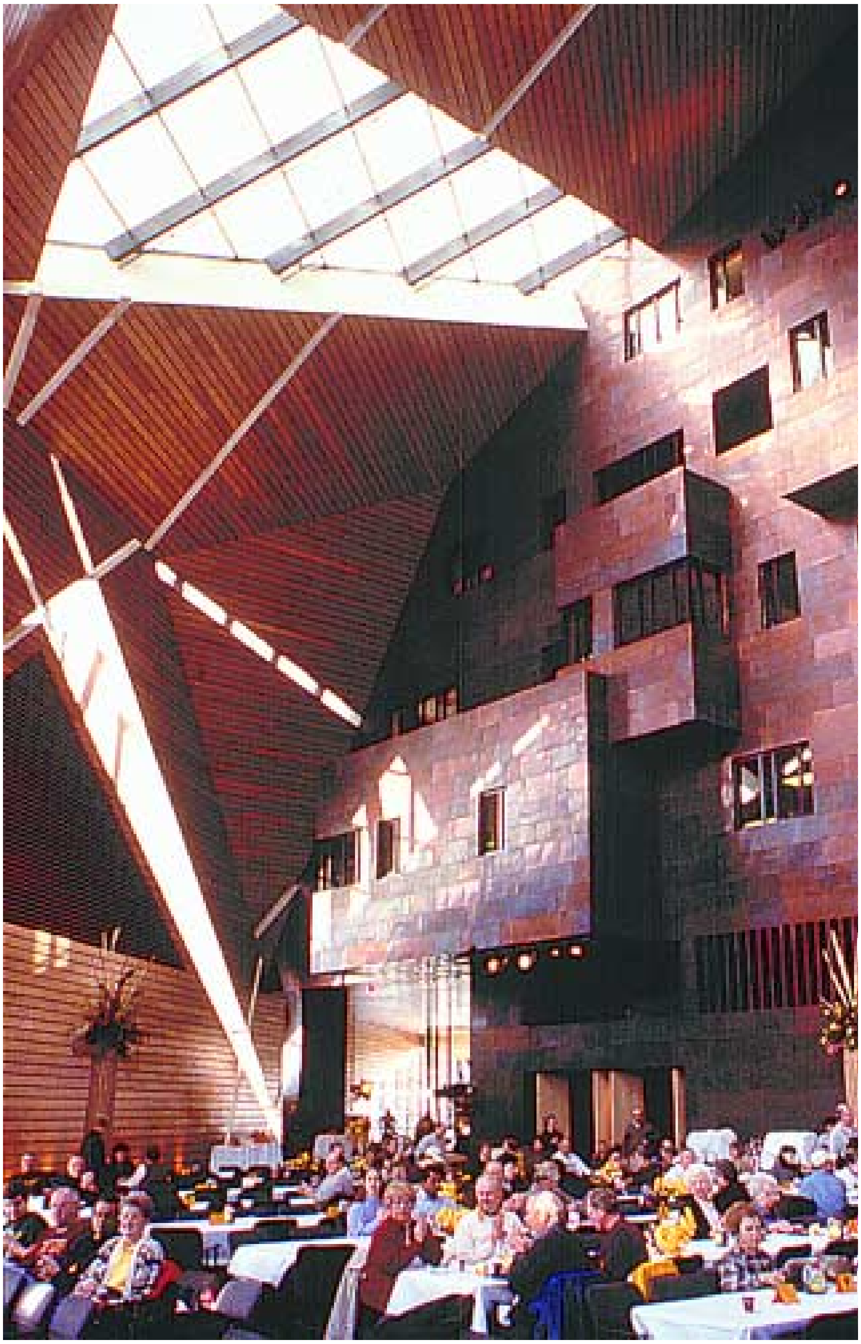
Unique support requirements: The structural supports at the top and the bottom of the Geode steel frame required design for unusually high permanent lateral loads, due to the sloped geometry and space frame nature of the framing. The foundation support system utilized special base plates with thrust bars, torsion resistant grade beams and battered steel piling. The lateral loads at the top of the steel frame were resisted by large embedded steel plates (up to 2′ x 4′ in size) cast into concrete beams, and ultimately transferred to concrete shear walls through the slab diaphragm.

Connection design: The severe geometry conditions resulted in several locations with up to eight steel beams framing to a common connection. Over 100 connection types were required. Typical buildings will generally have just five to 10 different steel connection types.

Sequential deflection analysis: For each surface the deflection patterns for four load components were studied, including initial steel framing, granite application, interior ceiling framing and applied live loads (snow, wind, and ice). These analyses were used to determine beam cambers and planning of granite erection. This was essential information to assist the contractor in providing the scheduled surface flatness.

Meeting and Exceeding Owner and Client Needs

MBJ engaged the owner in the early phases of the project by reviewing the options for structural systems for the Geode, including concrete shell, built-up, prefabricated steel trusses and conventional steel framing. The owner's representatives and their consulting and contracting team members were a part of intense weekly coordination meetings throughout the design period. This was a unique collaborative and team-building effort. MBJ regularly led the discussions and maintained detailed meeting minutes for this process.



Cost-effectiveness was achieved by choosing the appropriate framing system, working closely with the steel fabricators and using readily available steel framing members. MBJ played an important role in meeting the construction schedule on this structurally challenging building. A phased, multiple bid package, construction document delivery system was used to fast track the construction of portions of the building while others were still being designed. This unique negotiated construction process demonstrates how complex buildings can be built with aggressive schedules to meet the goals of the owner.

The final construction cost was slightly under the original budget estimate. This is remarkable for a building with great complexity and an expeditious construction schedule.

MBJ achieved success by meeting the goals and original concept of the owner. The success of this building relied heavily on the realization of the Geode's unusual and sophisticated structure. Referring to the goals and aspirations of this building endeavor, Margaret S. Carlson, current executive director of the University of Minnesota Alumni Association said, "What I truly believe about higher education is that people come here filled with potential and desire and that universities change lives. And then they go on to change the world. So if we could build a monument to that transformation of lives and then changing the world, it would be a great thing." Once the building was completed she added, "This building is a testimony to courage and determination and the power of collaboration among those who shared a seemingly impossible dream."

Jerod Hoffman, P.E. is Project Structural Engineer with Meyer, Borgman and Johnson, Inc. in Minneapolis.

PROJECT OWNER:
University Gateway Corporation (consisting of: University of Minnesota Alumni Association, Minnesota Medical Foundation, and The University of Minnesota Foundation), Minneapolis, MN

STRUCTURAL ENGINEER:
Meyer, Borgman and Johnson, Inc., Minneapolis, MN

DESIGN ARCHITECT:
Antoine Predock, Albuquerque, NM

EXECUTIVE ARCHITECT:
KKE Architects, Minneapolis, MN

GENERAL CONTRACTOR:
Mortenson, Minneapolis, MN

FABRICATOR:
LeJeune Steel Company, Minneapolis, MN (AISC member)

ERECTOR:
Amerect, Inc., Newport, MN

DETAILER:
NC Engineering Company, Burnaby, British Columbia, Canada

SOFTWARE:
AutoCAD