25 years of progress

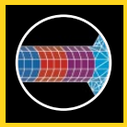
25 applications of success

ANSYS®

ZEPPELIN NT LZ N07

BOEING 777

SPACE SHUTTLE HIGH-PRESSURE OXIDIZER TURBO PUMP


IMAX THEATER

CLEVELAND SCHOOL OF SCIENCE PLANETARIUM

TELESCOPES

PACIFIC PLATE

BUILDING BEAMS

CULTURED MARBLE SINK

RAILWAY WHEEL

TROLL GBS OFFSHORE PLATFORM

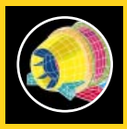
ARTIFICIAL KNEE

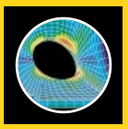
ALUMINUM BEVERAGE CAN

SHELL OIL BOTTLE

FORMULA ONE RACE CAR

AUTOMOTIVE FUEL INJECTOR


WATERJET PROPULSION UNIT

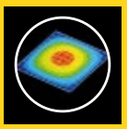

WIND ENERGY CONVERTER

CHARLES DE GAULLE BRIDGE

PLAY SLIDE

BLACK & DECKER STEAM IRON

INDUCTION-HEATED COFFEEPOT


SMITHSONIAN INSTITUTION PAINTING

“FISICROMIA” SCULPTURE

CHURCH OF OUR LADY IN DRESDEN

From humble beginnings...

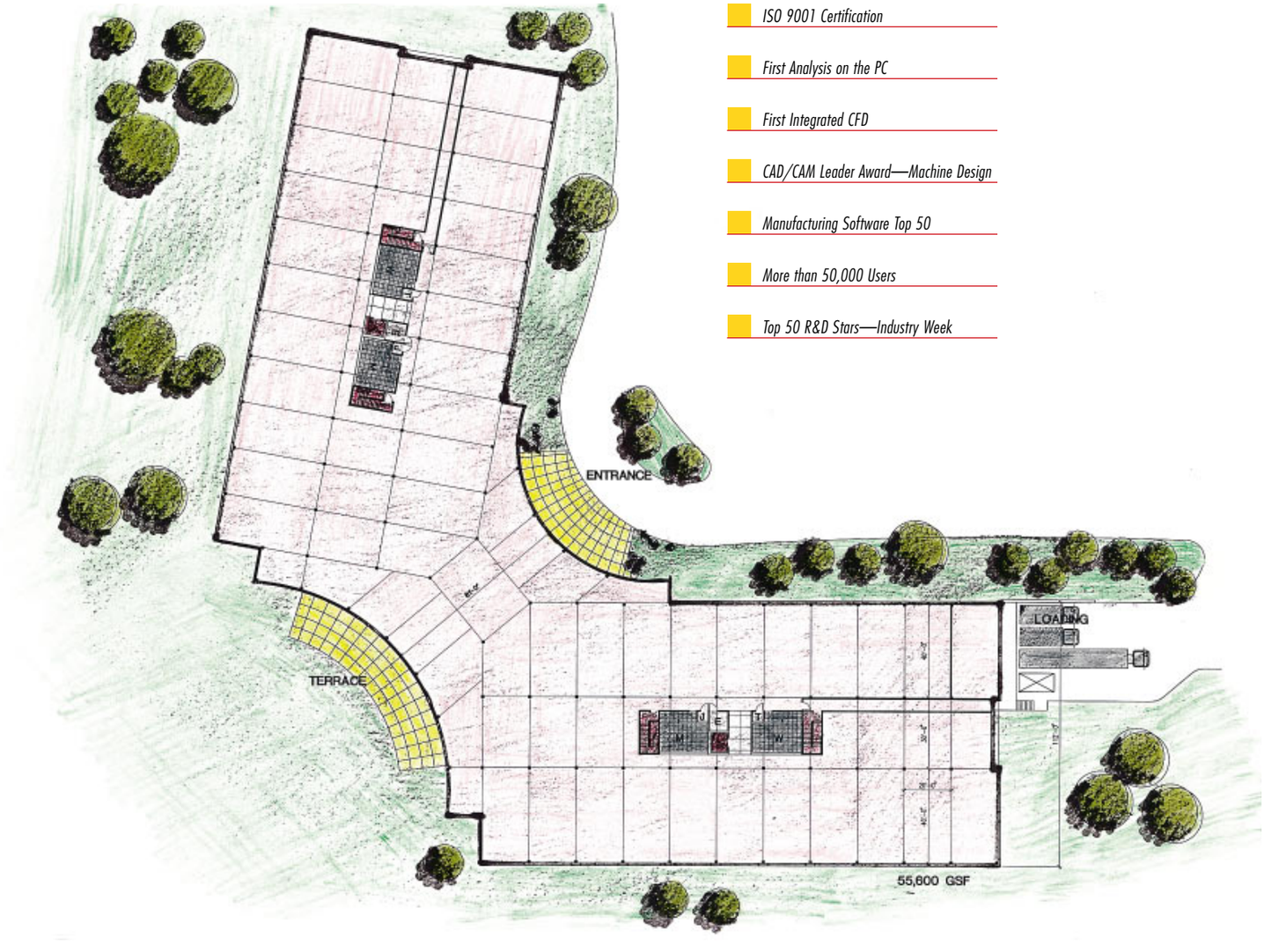
The ANSYS story parallels many of the entrepreneurial successes that dot the American business landscape. Like many before him, Dr. John Swanson, company founder and chief technologist, had a dream: that one day, all products would be designed, tested, and manufactured from within the computer. If he could integrate the mathematical equations that he used so frequently, as manager of structural design at Westinghouse Astro-Nuclear Laboratories in the 1960s, with emerging computer technology, he knew his dream would be fulfilled. ■ Dr. Swanson could envision the time when the computer would replace the engineer's handbook, just as calculators had supplanted slide rules; when engineers would use the computer to predict the effects of stress, temperature, pressure, and motion on a design; instead of investing in expensive prototypes and testing. He foresaw these developments not only because he recognized that technology had progressed to the point where his dream could be attained, but he also realized what this technology would do: slash design costs, shorten design cycles, and, most importantly, produce higher quality designs. ■ So like all visionaries with a dream, Dr. Swanson embarked on a mission to provide superior engineering analysis capabilities on the computer. That mission began in 1970 in a small farmhouse in Elizabeth, Pennsylvania, and with a single employee, John Swanson.

Dr. John Swanson

The first headquarters.

...Grew an international leader

Today, ANSYS, Inc. wears a much different face. That single employee back in 1970 is still here, but he now has 200 coworkers, including the industry-leading development team. That small farmhouse became office buildings, which soon will be shed like a jacket that's bursting at the seams for a technologically-advanced, state-of-the-art software development complex. The dream has blossomed into a multimillion-dollar-a-year international corporation with more than 50,000 users worldwide. ■ ANSYS is deployed by many major, multinational corporations, including the top 10 manufacturing companies in the *Global Fortune 100*. ANSYS technology is at work in design manufacturing organizations around the globe, as illustrated by many of the applications in this special, 25th anniversary book. This global presence developed for one reason: ANSYS technology continues to accelerate at a phenomenal rate. The company has added to its list of pioneering breakthroughs—first analysis on the personal computer (PC), first integrated computational fluid dynamics (CFD), advances in solver technology, first design analysis software company to receive quality certification under ISO 9001, etc.—with a track record for quality, reliability, and customer service. ANSYS continues to evolve to meet the needs of a rapidly changing world. Today, personal productivity tools are being replaced by flexible engineering systems and software that is tightly integrated throughout the product design process. ANSYS is partnering with customers and best-of-breed, third-party software providers to leverage ANSYS technology as the foundation of the flexible product design system of the future. The benefits of deploying ANSYS in this manner are obvious: reduced design costs, shorter times to market, higher quality designs, and improved competitiveness. The open ANSYS architecture creates flexibility. ANSYS is the only design analysis solution which provides 100-percent file compatibility across programs and platforms, from the PC to the CRAY®. That flexibility allows ANSYS to be used not only for design verification and virtual prototyping at the end of the product development process, but also early on to optimize designs and as part of manufacturing and production. ANSYS adds value through policies and services that help customers manage change, stay ahead of the competition, and make their existing investments in hardware and software more productive. ■ For ANSYS, customer success rests on providing high-quality products that are easy to use, technically advanced, multipurpose, multiplatform, fully compatible, integrated with major CAD systems, and open to customization. ■ Thinking of the customer's interest first is a philosophy that has been vital to the company's success over the past 25 years. And one that customers can count on for years to come.

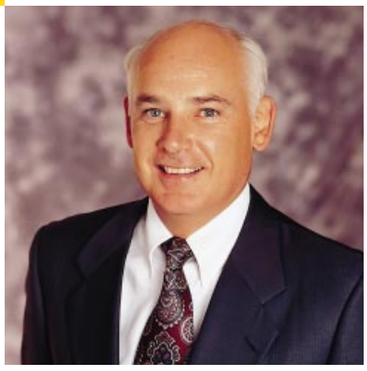


- *ISO 9001 Certification*
- *First Analysis on the PC*
- *First Integrated CFD*
- *CAD/CAM Leader Award—Machine Design*
- *Manufacturing Software Top 50*
- *More than 50,000 Users*
- *Top 50 R&D Stars—Industry Week*

25

25 years of service. 25 applications of success.

A LETTER FROM THE CEO



ANSYS, Inc. Celebrates 25 Years

A Legacy of Quality Products and Designs

A quarter century ago, Dr. John Swanson, a former Westinghouse engineer, began his own firm to commercialize the concept of computer simulation of engineering behavior, and became one of the pioneers of the technique known as finite element analysis. His vision and "brainchild," ANSYS, allows engineers to simulate behavior on the computer before building an actual product. Engineers now are able to experiment with many concepts before ever building an expensive prototype, giving them more confidence in their designs. ■ When ANSYS, Inc. began in a Pennsylvania farmhouse in 1970, most of its users were highly trained specialists with advanced degrees and the specific job function of performing engineering analyses. This was part of a design process in which analysis often was done in the late stages of a design to verify a product before it was constructed. ■ Today, analysis tools have become considerably less expensive and much easier to use, and are increasingly being put directly into the hands of design engineers and analysts alike. This trend means much broader market acceptance for ANSYS products; and a much stronger impact on technology, end-products, and people. The ANSYS program's applications run the gamut from biomedical implants to space shuttle design to nuclear reactors to a child's play slide. There even is a Formula One race car sporting the ANSYS logo in recognition of its role in the car's engineering. ■ No matter what the application, the ANSYS program is playing an undeniable role in helping to shape our world and its technology. Over the past 25 years, hundreds of our users have shared their ANSYS applications and have shown us how they are applying this powerful technology to help improve product quality, performance, and cost. ■ This year, as we celebrate our 25th anniversary, we take great pleasure in sharing some of these applications with you, as a tribute to John Swanson and to the thousands of engineers who are applying the powerful technology of ANSYS. Highlighted in this special, commemorative booklet are 25 unique and interesting customer testimonials of the ANSYS program, ranging from the transportation industry to fine art to industrial and consumer applications. ■ This broad range of ANSYS use across industry, across computers, and across the world has confirmed what we at ANSYS, Inc. have known for 25 years—ANSYS is the premier design analysis program, instilling confidence and reliability in product design cycles worldwide. ■ And, as ANSYS, Inc. gears up for the next 25 years of growth, many of our core principles and values remain the same as John Swanson's vision 25 years ago. We remain committed to providing the highest quality design and analysis products on the market today. We remain committed to our customers' needs when making business decisions. And we are focused on providing intuitive, intelligent solutions to worldwide engineering problems. ■ Our vision for the future includes our continuing focus to remain customer-driven, both from a technical and business standpoint. But, most importantly, as we look to the next 25 years, we recognize that our valued customers will always be the key to the continued success and growth of the ANSYS family of products. We have enjoyed serving your design analysis needs over the past 25 years, and we look forward to another quarter century (and beyond) of providing the engineering community with the best in reliable, innovative, quality products.

Sincerely,

PETER J. SMITH

President and CEO

25

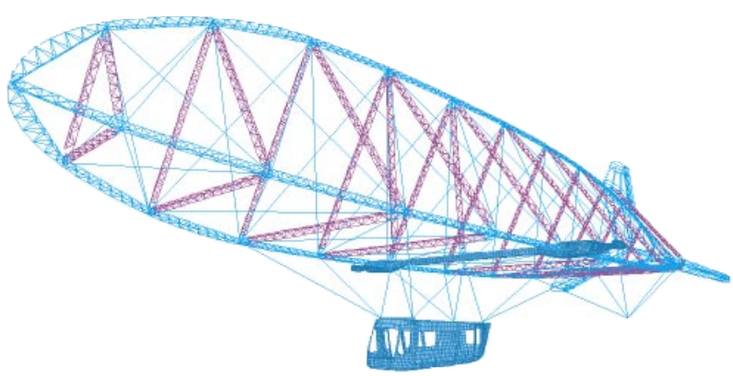
A quarter century of dedication to meeting engineering design challenges with ANSYS. Twenty-five years of ANSYS

progress and innovation, revolutionizing the way products are designed. To celebrate this era in the ANSYS story, 25 unique applications of success are described on the following pages. We are proud to be helping people solve design problems, big and small, from North America to Europe to Japan and around the world. We have helped launch the space shuttle and a Zeppelin, improved the safety of a child's slide, predicted the sliding of tectonic plates, explored uncharted territory with innovative waterjet propulsion systems, and designed an earthquake-proof telescope to chart the heavens. ANSYS has improved product quality, enhanced product design, reduced manufacturing costs, and expanded engineering boundaries. Over the last quarter century, ANSYS has had an impact not only on product quality but also on the quality of life. That's 25 years of success. We are looking forward to even greater achievements during the next 25.

"EVERY GREAT ADVANCE IN SCIENCE HAS ISSUED FROM A NEW AUDACITY

ZEPPELIN NT LZ N07

Zeppelins, lighter-than-air craft, were invented by Count Ferdinand von Zeppelin in 1908. An explorer, aviator, and inventor; von Zeppelin also fought in the U.S. Civil War. He designed and built his first dirigible, which was launched on July 2, 1900. By the time of his death, he had outfitted an entire fleet of German Zeppelins. ■ In the early 1900s, making the Zeppelin a safe craft was quite difficult. Flammable hydrogen, used for lift, and a fragile skeleton made bad weather flight risky. However, improved safety features, better technology, and stronger construction design have restored the Zeppelin as a viable airship for commercial and industrial uses. ■ Zeppelin Luftschifftechnik GmbH is developing a series of safe and economical airships which have surpassed all former designs. Engineers at Zeppelin have been testing a prototype in preparation for the maiden flight of the Zeppelin NT LZ NO7, planned for early 1997. ■ The new, rigid skeleton is designed to withstand the elements and allow year-round flight. The design team used the ANSYS program to test the frame for strength and stability under a variety of operating conditions. To allow for the pressurized hull, comprising helium-filled cells; the frame would have to withstand adverse weather, faster cruising speeds, and tighter maneuvering. ■ The ANSYS program proved to Zeppelin that the framework was safe and would not buckle under the various operating conditions. In the pioneering tradition of Count von Zeppelin, ANSYS has helped breathe new vitality into an historic and unusual aircraft.

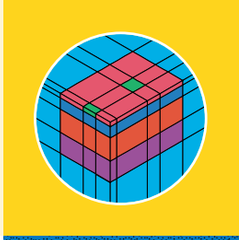


ZEPPELIN interior structural frame.

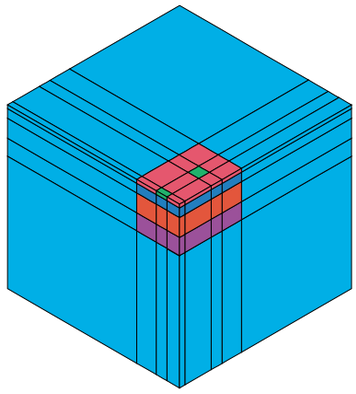
THE FIRST REGULARLY SCHEDULED AIR PASSENGER FLIGHT TOOK PLACE

BOEING 777

ON JAN. 1, 1914, WHEN A BENOIST FLYING BOAT TRAVELED 22 MILES.



Thousands of airplanes take off and land daily, taking travelers to business meetings, weddings, colleges, vacations, and honeymoons all over the world. Safety is something those hundreds of thousands of travelers may take for granted. Airplane manufacturers invest millions of dollars into engineering and design research to help ensure the safety of their airplanes. The Boeing Company, in preparation for the release of the 777 wide-body, which required a new landing gear design, performed numerous tests to verify the wheel load interaction of the main landing gear on runway pavement. The company contracted with Progresstech, Ltd. in Russia to perform field testing. The goal of this testing was to verify the design of the six-wheel landing gear, to ensure the airplane would not have a substantial impact on runway pavements, and to comply with airport standards for this airplane class. ■ The Federal Aviation Administration (FAA) spends more than $2 billion annually to maintain runways in conjunction with an initial $100 billion investment. Upgrading pavement deficiencies could require an enormous investment by the FAA. Substantial changes in the existing landing gear design, on the other hand, could cost the airplane manufacturer hundreds of millions of dollars or more. ■ Boeing used the full-scale test data from Progresstech, Ltd. and employed ANSYS to predict the pavement response to the landing gear in the underlying pavement layers. The ability of ANSYS to model structural behavior was critical in verifying the analytical results against the field data. ANSYS easily simulated the effects of stress, strain, and displacement; and served to illustrate the behavior of the different load ranges through realistic graphic displays. ■ ANSYS was chosen for the analysis because of its powerful modeling, analytical, and postprocessing capabilities. With ANSYS design optimization, Boeing and the new 777 jets were able to take off.

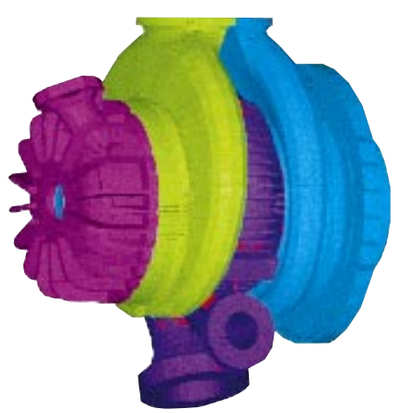


Volume plot of runway for the BOEING 777 project.

"THAT'S ONE SMALL STEP FOR MAN. ONE GIANT LEAP FOR MANKIND."

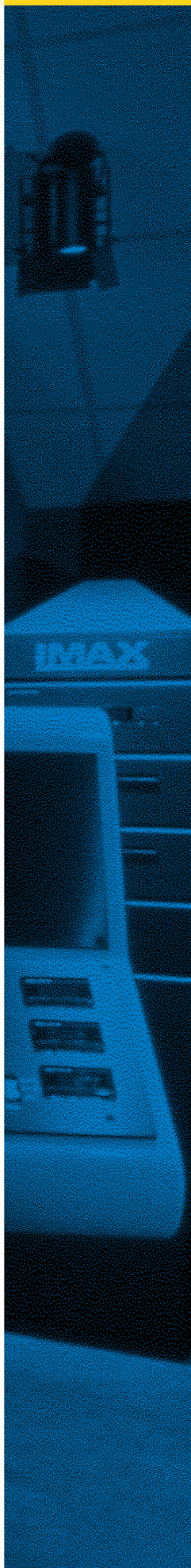
SPACE SHUTTLE HIGH-PRESSURE OXIDIZER TURBO PUMP

Have you ever wondered how vastly complex the engines and machinery must be to make the orbiting NASA space shuttles not just lift off, but actually break the earthly bonds of gravity, and soar through the solemn quietude of space? Each time the engines fire, people catch their breath as the shuttle sheds gravity's grip, and cheer as it breaks free to achieve orbit. ■ One of the on-board components is called a high-pressure oxidizer turbo pump, or HPOTP. The HPOTP is used to pump liquid oxygen (at -270 degrees F) to the shuttle. Originally designed in the 1970s, the turbo pump had to be redesigned because the previous design had a limited life span of only several thousand seconds. ■ Determined to increase the life span of the pump, Sverdrup Technology, Inc. needed a way to determine tolerances between the different sections of the pump housing. Close tolerances of just a few mils between these sections and the pump's extreme operating conditions can hinder measurement. Severe cold from cryogenic liquid oxygen and extraordinary pressure make it difficult to simulate actual performance in a normal laboratory setting. ■ Previous testing methods were inadequate, due to the complexity of the pump, and precluded a realistic test of the equipment. However, the measurement of these close tolerances was critical to the design. Only by measuring the clearances could vibration problems be anticipated and corrected. ■ Using ANSYS, 14 separate subassemblies of the pump were simulated, based on detailed drawing specifications. But the engineers needed to go one step further and see the interaction of all of the sections as a single working unit. Engineers on the project were able to employ ANSYS on a CRAY C916 supercomputer—the largest computer available at the time with a compute rate of 6 billion operations per second—to help visualize the working conditions of the pump. ■ Reducing the time to solution from one week to overnight for the shuttle oxidizer turbo pump makes computer-aided design decisions practical and achievable—even for large, 3-D models. The next time the shuttle lifts off, it's taking ANSYS with it.

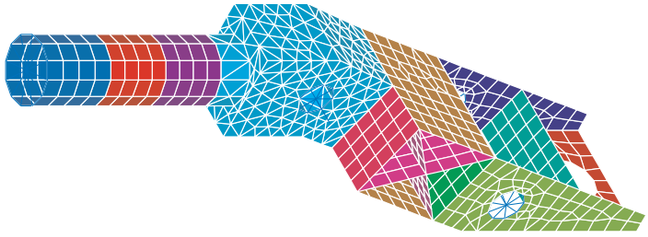


The high-pressure oxidizer turbo pump for the SPACE SHUTTLE.

A 45-MINUTE OMNIMAX FILM, STRETCHED OUT END-TO-END, WOULD WRAP



The IMAX® system has its roots in EXPO '67, where multiscreen films were the hit of the world's fair. A small group of Canadian filmmakers, who had made some of these popular films, decided to design a new system using a single, powerful projector rather than the cumbersome multiple projectors used at that time. Several elements work together to create the IMAX experience: the largest film frame in motion picture history projected on giant screens extending beyond your peripheral vision. It features the most advanced projector ever built, which is coupled with high-fidelity, six-channel, multiway sound, and is shown in specially designed theaters. IMAX films not only continue to be a prime attraction at EXPOs, but now are featured in 124 theaters in 20 countries. More than 50 million people saw an IMAX film in 1995. ■ ANSYS was used to optimize one of the critical components of the new IMAX projector. A steady, precisely controlled feed of film is crucial to guarantee the clarity characteristics of an IMAX film. A technique of rolling the film horizontally in a wave-like motion is used: each frame, in turn, is positioned by fixed pins and held firmly against the lens by a vacuum, at as many as 48 frames per second. An accurate positioning of the film in front of the lens is dependent on a set of deceleration pins. ANSYS was used to perform a structural analysis on the arm driving the motion of the pins. The arm directs the pins into the perforations on both sides of the film, thereby determining the rate at which the film is stopped in the aperture. One design requirement was for the end of the arm to deflect under the applied load by less than one-thousandth of an inch. The ANSYS simulation showed that the arm was twisting in the original design, and lead to a better, lighter, more rigid design. Vibration characteristics of the arm were also examined. ■ When operating performance is critical, ANSYS analysis proves to be a faster route to an optimum design. The potential of ANSYS to improve the efficiency of the design process continues to be demonstrated throughout the engineering industry, and the IMAX experience is but one fine example.



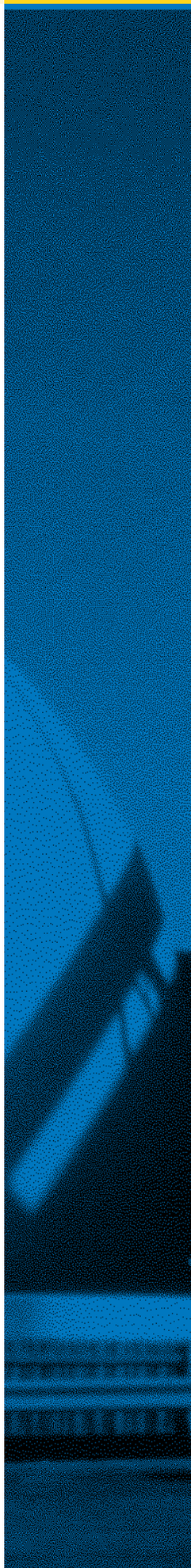
The IMAX PROJECTOR arm.

IMAX® is a registered trademark of IMAX Corporation, Toronto, Canada.

"SPACE IS REALLY BIG — REALLY BIG. YOU JUST WON'T BELIEVE HOW

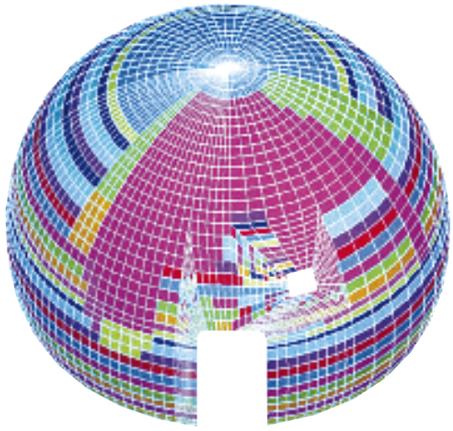
CLEVELAND SCHOOL OF SCIENCE PLANETARIUM

VASTLY, HUGELY, MIND-BOGGLINGLY BIG IT IS." Douglas Adams.



Stargazing is a romantic pastime for some and a serious avocation for others. For many years, planetariums have educated people about the stars by bringing those distant worlds closer.

There's something very humbling about exploring the farthest reaches of distant galaxies, or searching the heavens for uncharted stars. ■ So, when the concrete surface of the Cleveland School of Science Planetarium's dome began to decay and was in danger of collapse, many thought that more than a building was at stake. If the planetarium was demolished, Cleveland stood to lose an important community landmark. But, if the dome could be repaired, it would be necessary to ensure that the telescope and other equipment (valued at more than $1 million) would remain undamaged, because its removal was not feasible. At first, no one wanted to tackle the problem. ■ Anatek, Inc. was called in after other consultants already had recommended demolition. The company's engineers believed they could guarantee the dome's repair without damage to the building's contents and restore the original condition of the Planetarium's exterior shell. ■ In restoring the Planetarium dome, engineers also had to be particularly concerned with creating repair openings. The openings were necessary if repairs were to be made, but they had to guarantee that the dome's structural integrity would be maintained. ■ Using ANSYS, Anatek analyzed the dome and its ability to withstand the weight of snow and the forces of high winds. Due to the sheer size and shape of the dome, it was difficult to predict its reaction using conventional analytical techniques. "This type of analysis was practically impossible 30 years ago," said Gale Emig, president of Anatek, Inc. ■ The analysis confirmed what Planetarium officials had hoped—the dome could be successfully repaired. "Not only did we repair the building, but we also saved the owner approximately $800,000 in material costs. Today, the planetarium is a beautiful and useful structure, thanks to the ANSYS program," said Emig. ■ ANSYS has allowed the Cleveland School of Science Planetarium to keep reaching for the stars.



The PLANETARIUM DOME.

"AS WE ACQUIRE KNOWLEDGE, THINGS DO NOT BECOME MORE

TELESCOPES

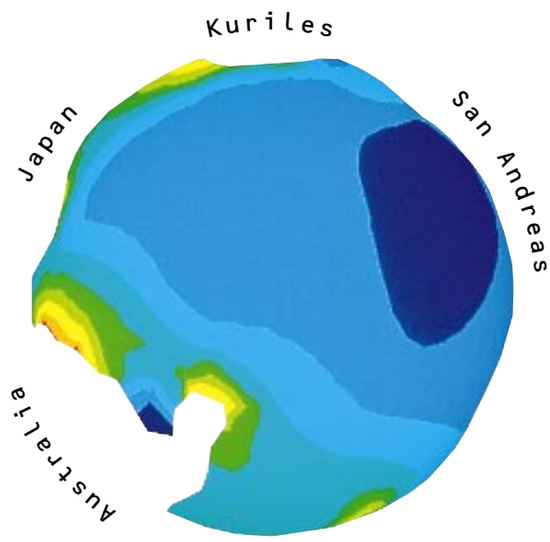
Infrared and giant telescopes help scientists observe the skies in search of clues to the origins of nearby stars, planets, and galaxies. Wormholes, quasars, and black holes– the stuff of science fiction—become science fact through the research afforded by this kind of equipment. ■ ROM Engineering, Inc. in Tucson, Arizona, performed a precision opto-mechanical analysis of a space-qualified infrared telescope. A system model consisting of a precision ANSYS structural model and an optical raytracing model was created. Such a model was required to determine the effects of optical surface deformations on image quality. If the optical surfaces should significantly deform under the temperature extremes of the space environment, the resulting image quality would be useless for the instrument's purposes. Optical tests were performed during thermal cycling of the telescope to provide a basis for fine-tuning the optical portion of the system model. Once obtained, this model will be used for subsequent design optimizations. ANSYS was the answer for the mechanical aspect of the model. The ANSYS-Pro/ENGINEER Interface™ saved many months of work. "Ten to 12 years ago, this 56,000-node model would have taken many months to create, making design modifications virtually impossible. It took only four days to create the Pro/ENGINEER® assembly and 15 minutes to create the finite element mesh," said Skip Radau of ROM Engineering. ■ ANSYS also helped conduct structural analyses on another telescope called the VLT (Very Large Telescope) planned by the European Southern Observatory (ESO), a scientific consortium comprising Belgium, Denmark, France, Germany, Italy, the Netherlands, Sweden, and Switzerland. The ESO plans to build the new VLT in 1996. The VLT will consist of four, 314-inch telescopes. In tandem, the telescopes can produce the resolution of a single 630-inch telescope. ■ Since the telescope will be used for scientific study, including measurements of distances to nearby galaxies, accuracy is critical. Any optical deviation caused by movement will produce measurements that could be inaccurate by millions of miles. Therefore, the telescope's ability to remain motionless is a key design consideration. ■ Structural deformation and stresses under micro-seismic "noise" and dynamic wind loads were analyzed using ANSYS. The ANSYS program showed the VLT to be very sensitive to ground movement. These results are being used to enhance the design of the VLT and its supports. ■ ANSYS capabilities open a window on a whole new universe.

The AVT INFRARED TELESCOPE.

"CIVILIZATION EXISTS BY GEOLOGICAL CONSENT, SUBJECT TO CHANGE WITHOUT NOTICE." Will Durant.

PACIFIC PLATE

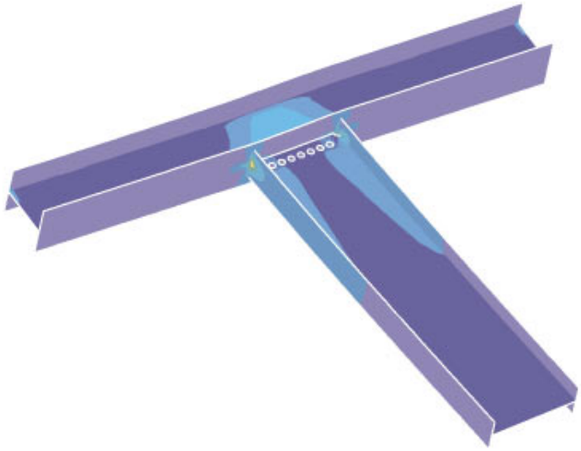
Earthquake. It's an event some may never experience, and for those who have, it is a terrifying loss of control—a lifetime lived in milliseconds. Fortunately, scientists have been studying the Earth's tectonic plates and the unique geological forces which cause them to move. By understanding these huge plates and their movements over millions of years, scientists may be able to predict how and when similar events may occur. ■ At the Department of Earth Sciences, Vrije Universiteit in Amsterdam, Dr. Fred Beekman and his team have been employing supercomputers and sophisticated modeling techniques to investigate how the Pacific plate interacts with others below the ground and the potential for earthquake activity. ■ As the Pacific plate moves, it can impact or even drag neighboring plates. Over millions of years, this kind of movement has resulted in many geophysical phenomena, including the formation of continents and volcanic activity. ■ By using the powerful capabilities of ANSYS, Dr. Beekman and other scientists have gained important insight into how the Earth's tectonic plates interact. Analyzing the geometry of the Pacific plate and the dynamic geological processes at work may help scientists predict when the stresses will reach a critical level. ■ Eventually, through the application of ANSYS, it may even be possible to develop an early-warning system for earthquake prediction, which may save millions of lives.



Stress plot of the PACIFIC PLATE.

"OUT OF EVERY DISASTER, A LITTLE PROGRESS IS MADE." The Control

The Los Angeles earthquake took its toll on hundreds of buildings thought to be earthquake resistant. Many structural beams, joined to support columns, failed at the weld points despite being deemed quake-proof under building codes at the time. ■ ROM Engineering, Inc. in Tucson, Arizona, has been studying the ways in which structural beams fail and which areas are most vulnerable to stress failure during a quake. Their goal is to help engineers and city planners understand the effect of earthquakes on construction, and to improve building codes in California. ■ By creating a model of beam connections in buildings and subjecting them to the crushing loads of an earthquake, ROM hopes to present several strategies which could be used to distribute loads more uniformly across the beam. ■ Earlier building codes were developed based on the school of thought that stress was evenly distributed during an earthquake. However, the ANSYS analysis showed the weld joints were most likely to fail. ■ Armed with proof from the ANSYS analysis, ROM is helping to convince California building officials to change the current beam connection designs. By changing these designs and improving the construction methods in California and other quake-prone cities; high-rises and homes will be more likely to survive an earthquake. ■ ANSYS can help improve building codes, affect legislation, and even save lives.

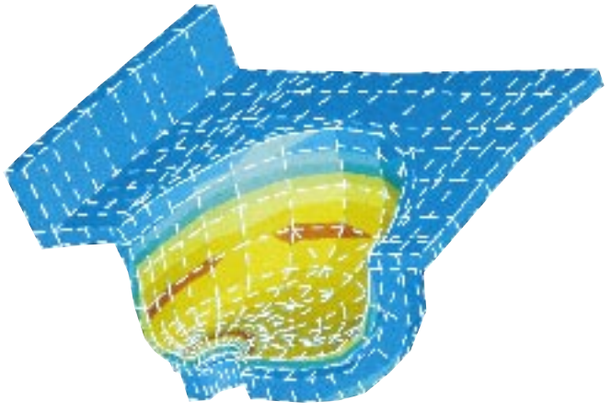


Stress display of STEEL BEAM connections under earthquake loading.

"ALL WILL COME OUT IN THE WASHING." Cervantes, *Don Juan*.

CULTURED MARBLE SINK

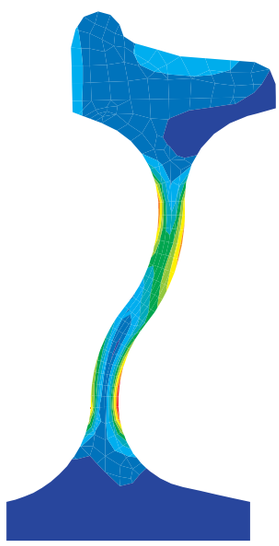
Early morning rituals of brushing teeth, shaving, and primping mean that many of our first waking hours are spent over the bathroom sink. The splash of ice-cold water is a shock to the system, the first thing in the morning. And it's not easy on cultured marble bathroom sinks, either. Cultured marble sinks are installed in thousands of bathrooms in homes throughout the world. These beautiful fixtures are known for their long-lasting quality. If a cultured marble sink should crack, it must be entirely replaced. ■ Cultured marble is a tough composite of thermoset resins and mineral fillers that is polished to achieve the lasting marble appearance. The composite must be tough enough to withstand the dramatic temperature changes from cold water to hot. Thermal shock failure cracking, which results from stress under extreme temperature changes, is a common industry problem among sink manufacturers. ■ ANSYS was used to analyze the effects of thermal shock failure on cultured marble sinks by engineers of Reichhold Chemicals, Inc. U.S.A. (known as Dainippon Ink & Chemicals, Inc. in Japan), which supplies unsaturated polyester resins for casting cultured marble sinks. ■ Finite element analysis helped to demonstrate how a variety of materials used in the cultured marble sink would be affected. ■ As a result of the ANSYS analysis, engineers were able to experiment with various combinations of fillers and determine which raw material worked best, without ever leaving the drawing board. ANSYS has helped manufacturers to improve designs and ensure that quality products are delivered to homes all over the world.



Stress results for MARBLE SINK.

THE WORLD HAS A TOTAL OF MORE THAN 14 MILLION MILES OF RAILWAY LINES.

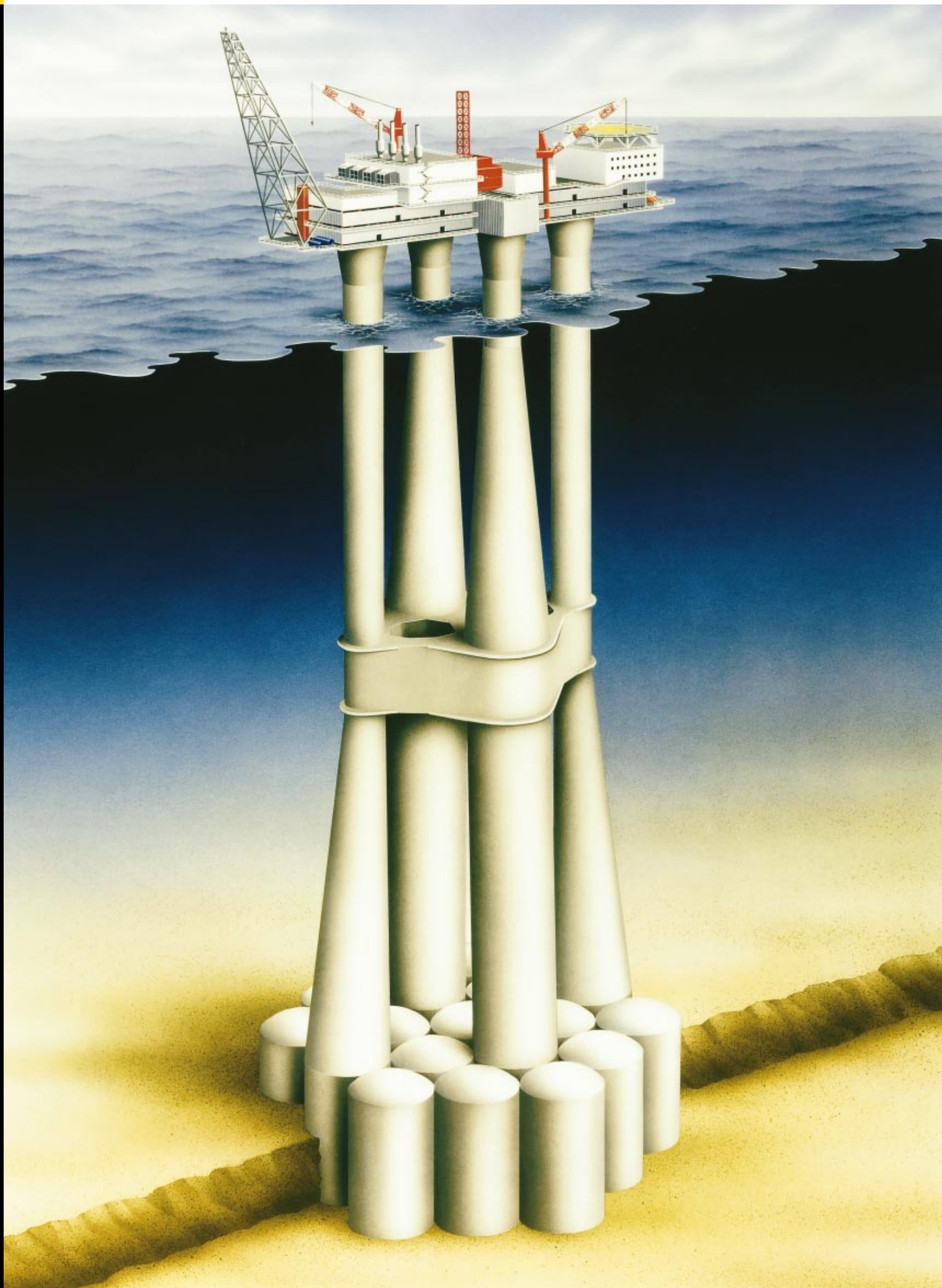
Railroad cars deliver a number of goods in many countries. Automobiles, produce, mined ore, cattle, and even construction equipment are delivered by railway. Often covering mountainous terrain or vast distances, railroad cars are subjected to the demands of enormous weight, constant vibration, and frictional heat. Their routes can leave them isolated and without immediate access to repairs, creating a great demand for increased reliability in manufactured parts. ■ The sustained loads and intense heat generated from wheel revolutions can pose serious metal fatigue problems, particularly on the wheel bearings. When INstitutul pentru Analiza Sistemelor (I.N.A.S.) in Romania was asked to test a new railway wheel design, engineers turned to ANSYS. ■ Before the new railway wheel could be manufactured and exported to the United States, the integrity of the design had to pass several rigid tests and be approved by the American Association of Railroads (AAR). To ensure the strength of the new wheel, I.N.A.S. conducted a thorough analysis to ensure thermal stresses and vibration would not cause fatigue failure. ■ Using ANSYS, I.N.A.S. engineers were able to optimize the design and prove that material volume could be reduced by 3 percent, which saved production costs. The overall stress on the railway wheel also was reduced by 28 percent, which made the wheel safer. ■ The design optimization capabilities of ANSYS allowed I.N.A.S. to meet the stringent integrity requirements of the AAR. With the help of ANSYS, a Romanian wheel manufacturer can provide a wheel at a lower cost, without sacrificing the structural integrity its customers needed.



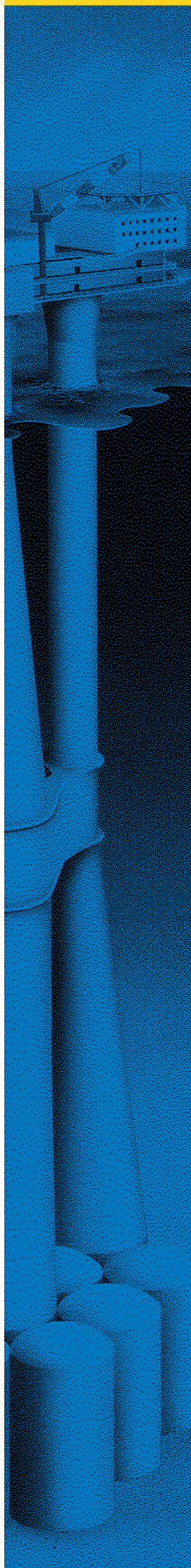
Thermal stress display of the RAILWAY WHEEL.

"ALONE, ALONE, ALL, ALL ALONE, ALONE ON A WIDE, WIDE SEA."

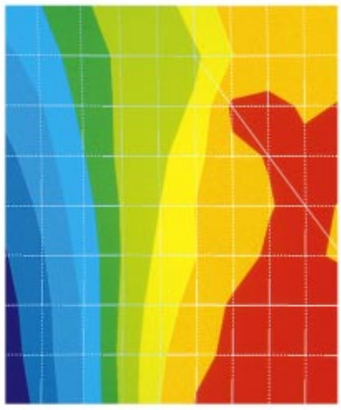
TROLL GBS OFFSHORE PLATFORM



Samuel Taylor Coleridge, *Ancient Mariner*.



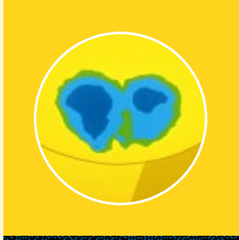
Imagine the isolation of offshore drilling crews, working round-the-clock shifts and braving the cold waters of the North Sea. Every man and woman on the crew, each a highly trained specialist, has families and friends back home. For these men and women, it's important to know their safety has been protected by the vital engineering analysis provided by ANSYS. ■ The world's tallest offshore concrete platform, the Troll GBS, is an engineering marvel. Only several meters shorter than the Empire State Building, most of its 221,000 cubic meters of concrete is underwater. ■ Grøner Multiconsult Joint Venture needed an efficient tool to perform nonlinear analyses of critical sections. ANSYS was a natural choice. ■ "What made the ANSYS program stand out from the rest was its nonlinear capabilities and efficient solvers. It only took two hours to run the problem on a computer workstation, which is extremely fast," said Henrik Grosch, an engineer at Grøner A.S. ■ The North Sea's high winds and churning surf conditions can create strains on any type of offshore platform. The biggest benefit of ANSYS was identifying necessary changes in the early stages of design, before investing in prototyping. ■ Because the Troll GBS consists largely of concrete, ANSYS was used to study the stresses, strains, and crack patterns in a detailed area. Using supercomputers to conduct the analysis, engineers were able to observe the potential failure points in the reinforcement and concrete; including the material's ability to crack, crush, or yield. ■ Preserving the safety of the Norwegian crews who staff these rigs is Grøner Multiconsult Joint Venture's main concern. ANSYS shows them how.

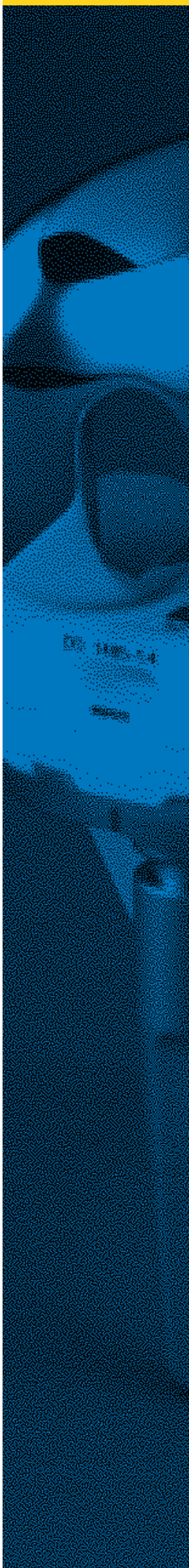


Principal comprehensive stress distribution at the end of the reinforcement bar for the ***TROLL GBS PLATFORM****.*

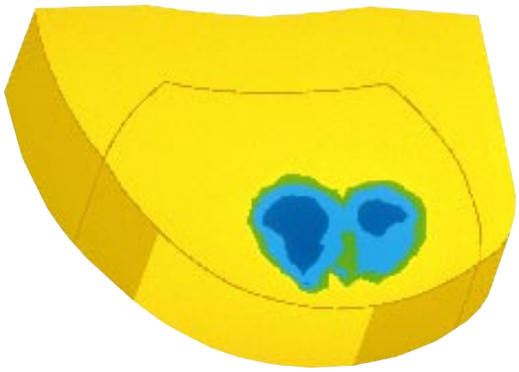
"I COULD HAVE PLAYED FOOTBALL FOR TWO OR THREE MORE YEARS.

ARTIFICIAL KNEE





People disabled by certain diseases or injuries often rely on artificial hip or knee joint replacements to walk again. For orthopedic manufacturers, the knee is the most difficult joint to duplicate. When DePuy Inc. was trying to develop a longer-lasting artificial knee, they used ANSYS software to find ways to decrease stress between the upper and lower articulating surfaces of the joint. ■ One of the critical design goals was increasing the contact area between the upper and lower portions of the joint. By increasing contact area, the company hoped to spread out the stresses in the joint, ultimately producing a product that lasted longer when implanted into patients. Rather than investigating contact with pressure-sensitive films as they had done previously, DePuy engineers used ANSYS to precisely determine the interaction between the top and bottom segments. ■ "Not only did FEA (Finite Element Analysis) give us a better picture of stresses in the joint than in the pressure-sensitive film, it didn't require building a prototype," said Paul Tomaszewski, DePuy analytical development engineer. "For early iteration, no prototypes were built, and our estimate is that the overall cycle for this product was reduced by 20 percent by using FEA," Tomaszewski observed. Also, since no prototype was needed, results were acquired sooner, which facilitated quicker design decisions. ■ By evaluating stresses on the joint while the design was in progress, ANSYS helped the orthopedic manufacturer create a knee implant with twice as much contact area, compared to the company's previous model. For the patients who depend on these artificial joints, they now have the support of a longer-lasting and higher quality product.



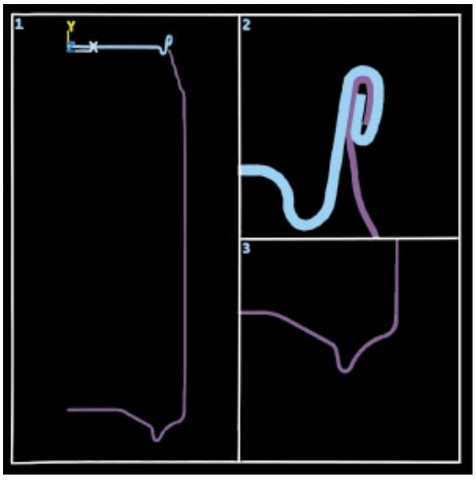
Stress display of the ARTIFICIAL KNEE.

"IT IS ONLY LIQUID CURRENTS OF THOUGHT THAT MOVE MEN AND

ALUMINUM BEVERAGE CAN

Who doesn't know the distinctive sound of a cold can of soda being opened on a blistering summer day? That cool liquid is refreshing and rejuvenating after we've sweltered in the hot summer sun.

It's an invention many take for granted. Although billions of dollars each year are spent on soda pop, the package is probably not appreciated nearly as much as its contents. Reynolds Metals Company, a major supplier of aluminum products—including pull-ring cans—does. ■ This Richmond, Virginia-based firm is growing through a strategy of record-setting product innovations designed to reduce manufacturing costs and improve quality. The application of ANSYS plays a key role in the success of this dual strategy at Reynolds. ■ By using ANSYS, engineers are able to model aluminum beverage cans, predict the effects of design changes, and analyze their impact on structural integrity. Using these sophisticated modeling techniques, Reynolds can reduce the weight of the can by using less aluminum, thus conserving resources while reducing production costs. ■ In addition, a variety of designs can be explored with ANSYS before product manufacturing. This allows Reynolds to bring cans to market sooner, and lets bottling companies deliver more thirst-quenching soda to consumers faster. ■ ANSYS allows product designers to explore more efficient product designs so that resources, such as aluminum, are not wasted. ANSYS helps protect the environment, while helping companies grow.



Display of entire ALUMINUM CAN cross section in window one,

closeup view of the top joint of the can in window two, and closeup view of the bottom of the can in window three.

"YOU CAN ONLY HAVE TWO THINGS IN LIFE, REASONS OR RESULTS.

SHELL OIL BOTTLE

Today, much of the packaging found in homes is made of plastic. Now, with increased emphasis on reducing the volume of solid waste produced, manufacturers are working to minimize the amount of material used in plastic packaging. ■ Providing an unbreakable container is a key benefit of plastic. And major container manufacturers face the challenge of getting more strength out of less plastic. The goal is not only to achieve production savings and improve profitability but also reduce the burden of plastic in domestic waste. ■ The ANSYS design optimization capabilities allow plastic extrusion companies to fine-tune blow-mold designs and increase the strength of plastic containers. Part of the process involves identifying the areas of potential failure. By manipulating the location of plastic, and moving plastic from non-load-bearing surfaces to areas where it could add substantial strength to the overall bottle, engineers at Invetech, Ltd. of Australia minimized the amount of plastic needed to create a safer and stronger package. ■ ANSYS was used by Invetech to help major clients such as Shell Oil Australia break previous strength boundaries. ANSYS allows design engineers to create alternative models and test them before prototyping—long before money is spent on product manufacturing. Overall strength was improved by 25 percent and, at the same time, 10-percent less plastic was required for the Shell Oil bottle. ■ Until now, blow-molding techniques used in the manufacture of the Shell Oil bottle have remained an uncharted domain for advanced design techniques such as ANSYS. But these advanced techniques allow companies to produce containers that give them more control over the entire manufacturing process. With ANSYS, the optimum design for a container can be achieved at less cost and in less time. ■ Every year, Shell Oil Australia produces more that two million containers. By employing the design optimization capabilities of ANSYS, the company has reduced the amount of plastic waste by 40 tons per year. Future generations will have a cleaner place to live because ANSYS provided solutions.

The SHELL OIL BOTTLE.

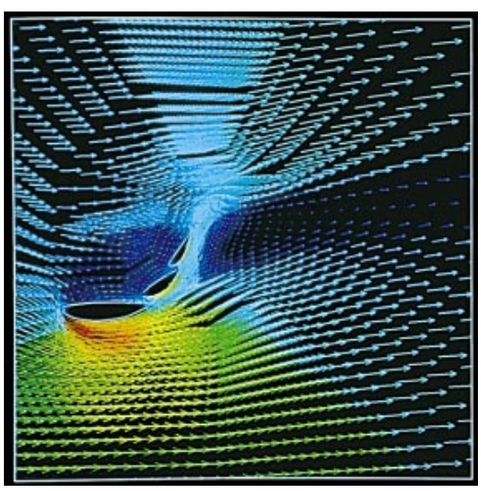
"I GOT MY FIRST GO-KART WHEN I WAS FIVE, AND I REMEMBER THINKING

FORMULA ONE RACE CAR

SOME DAY I WOULD RACE AT INDY." Scott Brayton, Driver.

Watching Formula One cars weave through traffic on a racetrack is intense, thrilling, and breathtaking. Every one of these aerodynamic beauties is more than just four wheels and an engine.

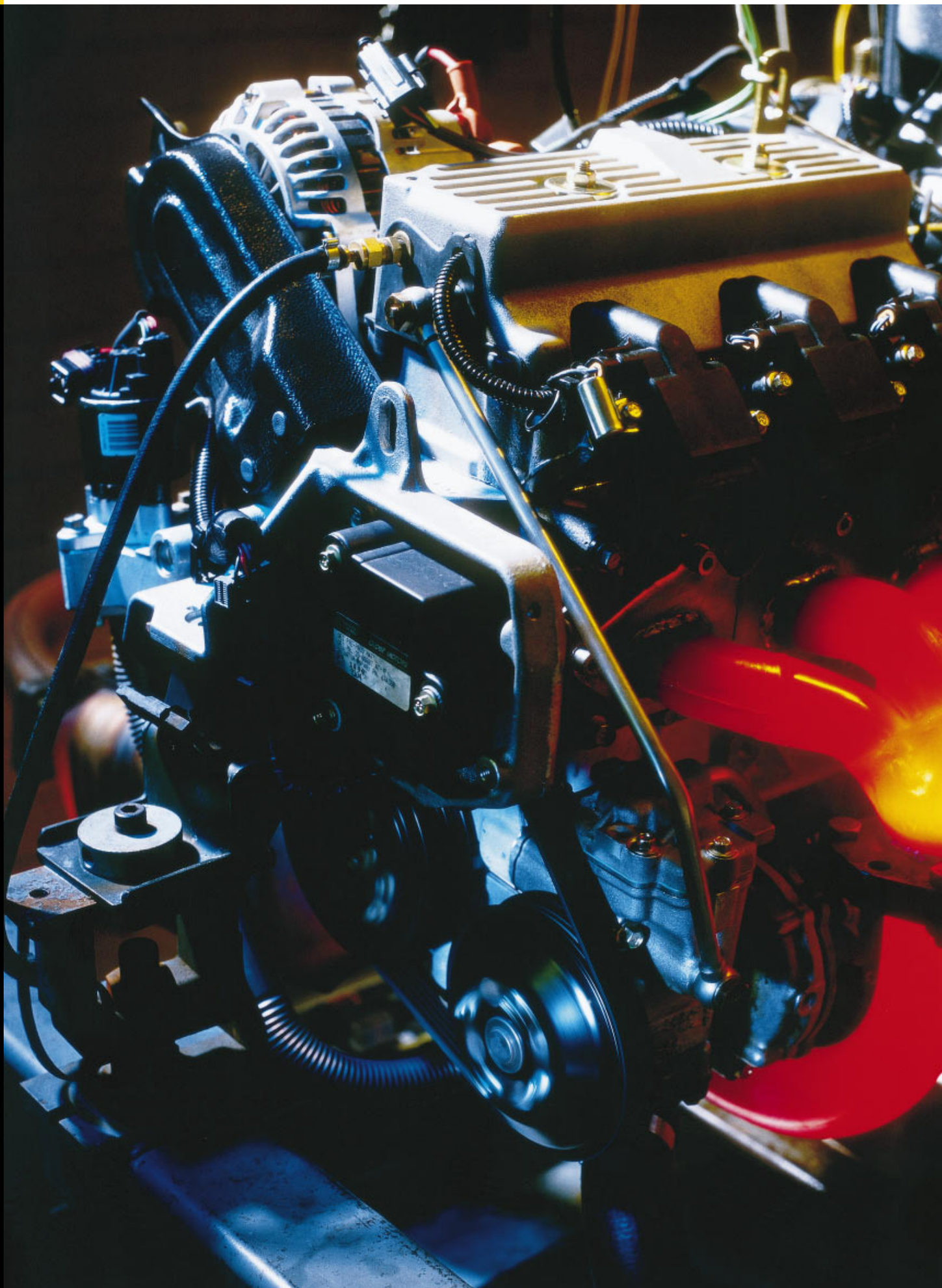
Substantial engineering, technology, and construction go into each one. ■ The capabilities of FLOTRAN®, fully integrated into the ANSYS program, are ideal in helping engineers understand the effects of turbulence, lift, and drag on racing vehicles. ■ Considerations of airflow and the potential drag generated by the aerodynamics of a car's design are key to optimizing design standards for the rear airfoil wing. This airfoil is critical to helping drivers maintain control at high speeds. Prior to the application of simulation technology, most car designers had to invest in building prototypes and conducting wind tunnel tests to track velocities and their effects on the rear wing. ANSYS/FLOTRAN™ has fueled quicker and more efficient means for testing these effects. ■ Ultimately, superstars of the Formula One world have benefited from redefining the aerodynamics of their cars with ANSYS/FLOTRAN, because it has helped them stay winners.



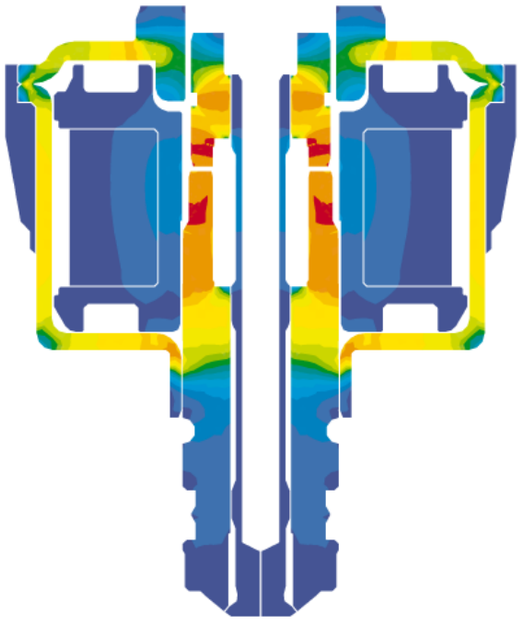
Vector plot of fluid velocities around the airfoil of a FORMULA ONE RACE CAR.

"WHY DO THEY CALL IT RUSH HOUR WHEN NOTHING MOVES?"

AUTOMOTIVE FUEL INJECTOR



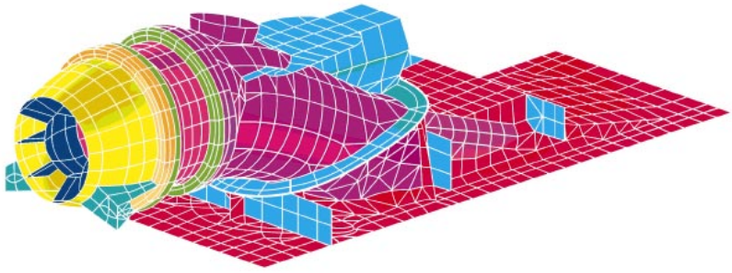
Automobiles, chain saws, scooters, and marine outboard engines are dependent on nonrenewable fossil fuels. Today, the industry is concentrating on new ways to make engines lighter, yet more efficient. This includes technology called the Orbital Combustion Process (OCP), which can improve fuel efficiency and reduce pollution. ■ Orbital Engine Company, Ltd. is a leader in the design, testing, and manufacturing of the OCP. The key to the Orbital engine lies in its design simplicity and precise electronic and mechanical control, which maximize power while minimizing fuel consumption and exhaust emissions. To achieve the optimum design "power-to-weight" ratio, engineers at Orbital Engine Company turned to ANSYS. ■ The full capabilities of ANSYS were brought to the forefront of the optimization process. Thermal, structural static, dynamic, and even electromagnetic capabilities were used. Both hot and cold analyses were conducted to determine levels of mechanical distortion and their impact on operating efficiency. ■ The ANSYS analysis helped engineers produce a highly durable engine, which minimized fuel consumption without sacrificing power at all levels of operation. ANSYS also was valuable in managing the dynamic characteristics of noise and vibration during operation. This has not only made the engine more efficient, but quieter, too. ■ Some of the world's major automotive and marine engine companies, including Ford, General Motors, and Fiat, have licensed the OCP technology from Orbital. ANSYS design optimization capabilities help emerging technology gain worldwide acceptance.



ORBITAL ENGINE fuel injector magnetic flux density.

"THE WINDS AND WAVES ARE ALWAYS ON THE SIDE OF THE BEST NAVIGATORS." Edward Gibbon, *Decline and Fall of the Roman Empire*.

In 1960, the first boats to ever travel up the Colorado River through the Grand Canyon were equipped with a Hamilton Jet waterjet propulsion system. And, in 1977, the great adventurer and explorer, Sir Edmund Hillary, launched his expedition "Ocean to Sky" on the Ganges River in boats outfitted with Hamilton Jet waterjet propulsion engines. Today, many naval and rescue vessels are furnished with this innovative propulsion system. ■ The waterjet propulsion system was developed in 1953 by Sir William (Bill) Hamilton, the founder of C.W.F. Hamilton & Co., Ltd., based in Christchurch, New Zealand. ■ Sir William's pioneering spirit and commitment to product innovation led his engineers to study ways of improving the design and construction of the waterjet. Their goal was to maximize the thrust forces generated and transmitted through the unit, while limiting the stress on the engine. ■ A working engine, with its moving parts and complexity of dynamic forces, can make design studies extremely challenging. ANSYS allowed engineers to successfully and accurately model the complex castings of the waterjet unit. Using ANSYS, it was possible to simulate and analyze the steering deflector, an integral part of the steering mechanism. ■ ANSYS design optimization capabilities allowed Hamilton engineers to achieve a lighter design, verify the integrity and reliability of the steering deflector, and help launch the product faster. ■ Mike Hamilton, chief engineer and grandson of Sir William, concluded, "Because the design optimization capabilities of ANSYS were carried out automatically, we saved time and money. But, most important, we were able to maintain our longstanding commitment to provide our customers with quality products and innovative design." ■ With ANSYS, C.W.F. Hamilton & Co., Ltd. can continue this commitment, and create waterjet propulsion systems that may capture a place in history for a long time to come. Who knows where the next adventure will lead?

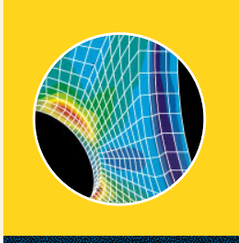


The HAMILTON JET WATERJET PROPULSION UNIT.

THE EARLIEST WINDMILLS WERE USED IN PERSIA, MORE THAN 2,000

WIND ENERGY CONVERTER

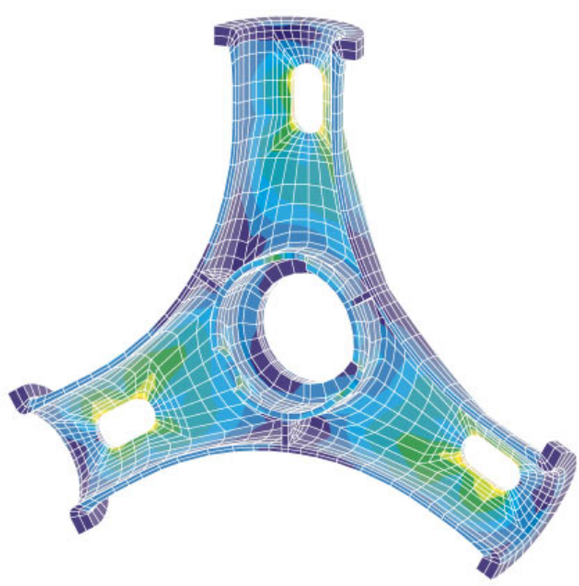
YEARS AGO, FOR THE GRINDING OF GRAIN.



Since the fifth century A.D., windmills have been a unique energy source. The first windmills were used to pump water or turn the grindstones of grain mills. Today, rural areas and many countries are attempting to better harness the power of the wind, a free energy source, with wind energy converters. This alternative energy source is slowly gaining appeal for both consumer and industrial applications, due to the rising costs of other forms of energy. Someday, these alternative generators of power may provide a greater portion of the world's energy.

■ A converter looks like a huge aircraft propeller mounted atop a tall shaft. The rotor hub of the converter can be as big as nine feet in diameter, and is the link between the blades and the shaft. These modern windmills also have a motor which turns the blades to keep them facing into the wind at all times. ■ Germanischer Lloyd, an international classification society for safety and quality control, was asked by the manufacturers of wind energy converters to ensure that they could withstand punishing winds and perform as needed. Germanischer Lloyd chose ANSYS to analyze the critical areas of the rotor hub. ■ With ANSYS, they conducted a fatigue analysis to understand the stress ranges on the rotor hub and provide a reliable set of data.

■ In Germany, ANSYS is helping to produce cleaner forms of energy and to reduce our reliance on fossil fuels.



Stress results on the WIND ENERGY CONVERTER rotor hub.

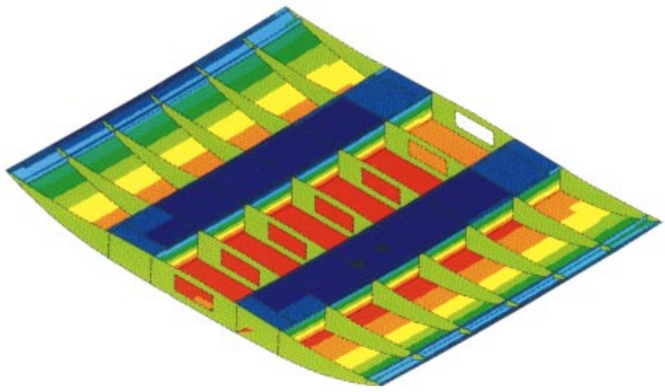
IN 1717, BRIDGE DESIGN BECAME A SCIENCE WHEN HUBERT GAUTIER

CHARLES DE GAULLE BRIDGE

WROTE THE FIRST TREATISE ON BRIDGE BUILDING.

Bridges are an endless source of fascination for those who travel over them. The architecture, construction techniques, and design ensure the safety of the people who cross them everyday.

Whether made of steel, concrete, or a combination of materials; bridges pose some unique engineering challenges. ■ When the Centre Technique Industriel de la Construction Métallique in Paris, France, and Computer Control Systems, S.A. in Athens, Greece, became partners to design the Charles de Gaulle Bridge, they turned to ANSYS. The unique challenges of the project required sophisticated analysis techniques. Planned as a combination of steel and concrete, complex erection procedures were needed to ensure its structural integrity. ■ ANSYS provided the right tools to help design the bridge elements. Engineers used ANSYS to model and analyze the entire bridge. Because of the enormous amount of computational time involved, traditional modeling techniques were considered prohibitive. ANSYS offered a modern and reliable way to overcome these problems. ■ The design capabilities of ANSYS were used to optimize the thickness of the steel beams used in the bottom shell, which supports the concrete road surface. Introducing ANSYS in the earliest engineering and design stages helped to accomplish what traditional methods could not. ANSYS can help engineers bridge the gap between planning and construction.

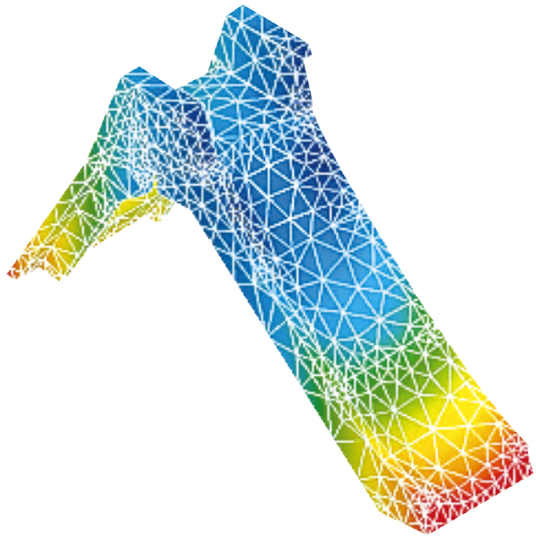


Stresses in the CHARLES DE GAULLE BRIDGE.

"THE BEST WAY TO MAKE CHILDREN GOOD IS TO MAKE THEM

PLAY SLIDE

Who doesn't remember the childhood fun of shooting down the slide at the local playground? Children everywhere squeal delightedly as they careen to the bottom of the slide to land in the waiting arms of mom or dad. ■ Today, by blending ingenuity with high technology, low-density polyethylene resin is used to make slides safer, less expensive, and easier to manufacture. Today's Kids®, a leading manufacturer of children's toys, was experimenting with ways to improve the overall quality of their products. Traditional and experimental prototyping methods were costly and time-consuming. ■ Engineers were sure the application of analysis software as a design tool would help them to significantly improve the quality of their product designs while, at the same time, reduce production costs through more efficient use of materials. ■ After some consideration, the Today's Kids engineers decided the best way to proceed was to "test drive" analysis software on an existing product—one that was representative of the kind of problems typically encountered. They chose the Play Slide because they already knew where the structure could fail from previous overload tests. Finite element analysis was then conducted using a variety of programs. ■ Only ANSYS was able to seamlessly interface with the existing CAD program, making it the clear leader for ease of use and broad range of capabilities. With the assistance of DRD Corporation, Today's Kids ANSYS representative, the overload test results of the Play Slide were pinpointed using ANSYS. This gave the engineers at Today's Kids confidence that ANSYS was the right tool for their applications. ■ Parents can be assured that ANSYS, with its technical accuracy and flexibility, is helping engineers design "childhood favorites" that are higher in quality and more affordable, providing countless hours of safe, enjoyable fun.



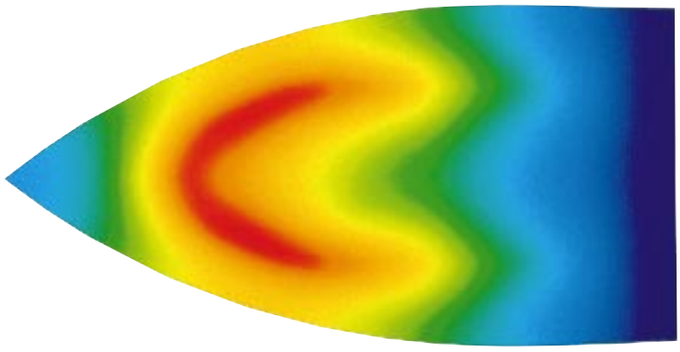
Displacements for the TODAY'S KIDS PLAY SLIDE.

"STEAM IS NO STRONGER NOW THAN IT WAS A HUNDRED YEARS AGO,

BLACK & DECKER STEAM IRON

BUT IT IS PUT TO BETTER USE." Ralph Waldo Emerson.

Today's fabrics need special care, especially during ironing, to make them look and feel their best. There's simply no better way to remove wrinkles from clothes than with a hot iron and a couple bursts of steam. Therefore, consumers are quite particular when it comes to choosing an iron. There are three key features which consumers want most when buying this home appliance: an even distribution of heat, lots of steam, and lighter weight for maneuverability. ■ Moalem Consulting, Inc. was asked by Black & Decker to tackle a new product design that would meet these objectives. The engineering team at Moalem believed that redesigning the soleplate (the part that comes in contact with the fabric) was the key to improved performance. ■ Moalem chose ANSYS, with its nonlinear thermal analysis capabilities, to test various soleplate concepts. The ANSYS design optimization program helped engineers create an iron with more steam and a faster heat recovery rate. ■ The new soleplate increased the rate of steam by 40 percent; while reducing the amount of materials used by 20 percent; to produce a lighter, more efficient iron. "The ANSYS simulation of the product performance allowed us to obtain a higher steam rate and better temperature distribution during all modes of operation ... and, at the same time, cut material usage," said Fred Moalem, president of Moalem Consulting, Inc. ■ The new iron, called "SurgeXpress™," is more maneuverable and makes it easy to get out wrinkles. And thanks to Moalem Consulting, Inc. and ANSYS, Black & Decker was able to develop the soleplate in just six months—three months less than previous development cycles. ■ With ANSYS, it's easy to surge ahead of the competition.

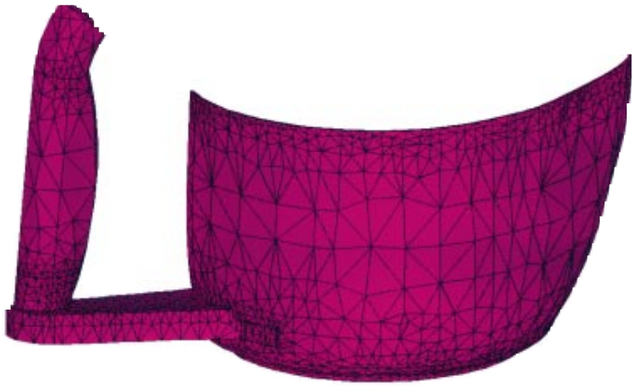


Temperatures for the IRON SOLEPLATE.

"SATTINGER'S LAW: 'IT WORKS BETTER IF YOU PLUG IT IN'." Arthur

INDUCTION-HEATED COFFEEPOT

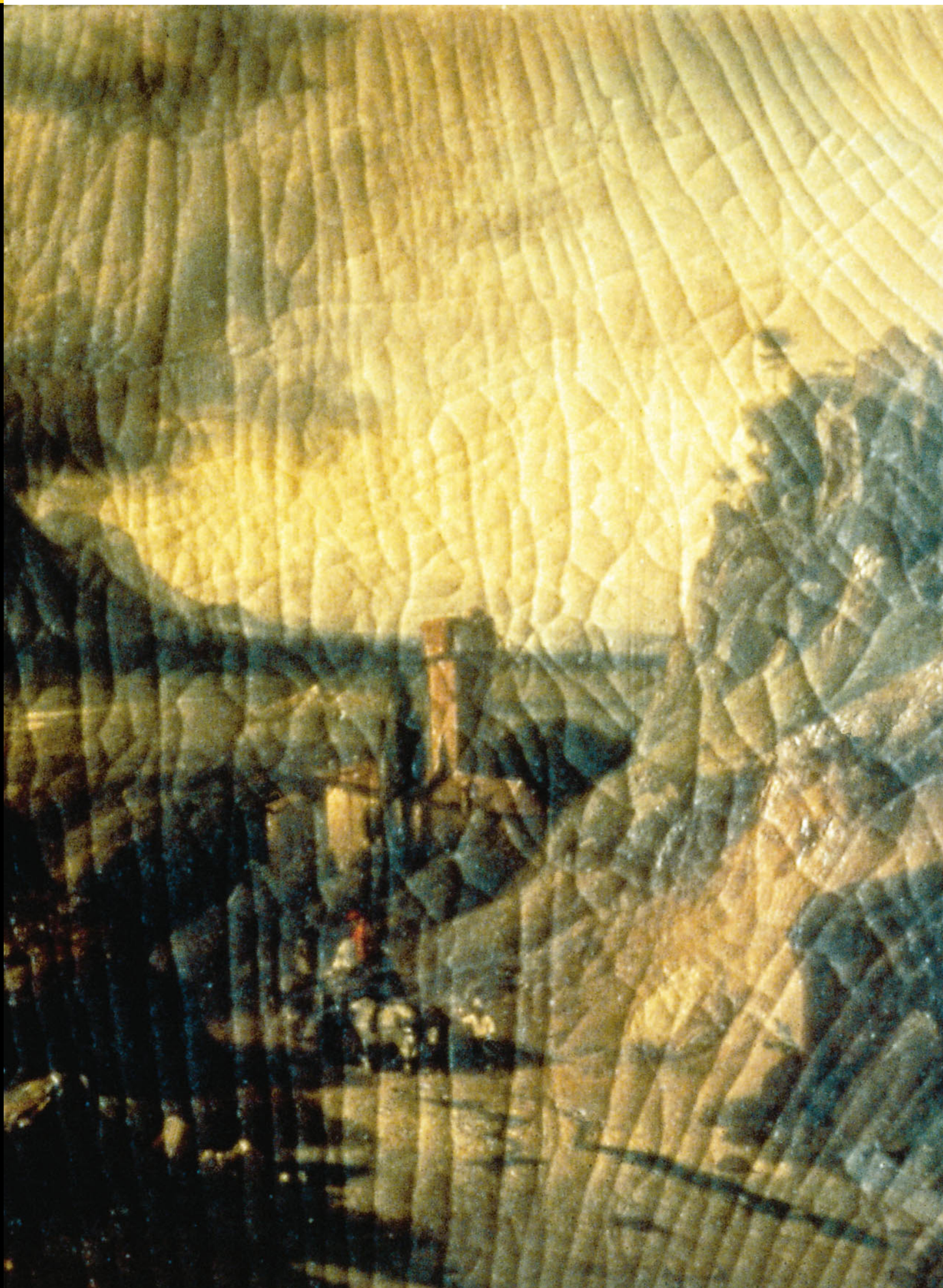
A steaming cup of hot coffee "jump starts" many people in the morning. Over the years, glass, aluminum, and other metals have been used in manufacturing coffeepots. But limited natural resources, such as aluminum, are causing companies to approach appliance manufacturing from radically new directions. ■ Structural Analysis Engineering Corp. (SAEC)/Kinetic Vision has applied a new and innovative approach to the ordinary coffeepot. The engineers wanted to test a design which would substitute low-cost plastic for certain metal components of an electric coffeepot. By studying other designs using molded plastics, engineers were convinced that the same principles would apply. ■ Of course, they also had to be sure standard thermoplastic materials could withstand the high temperatures (200 degrees F) needed to brew a fine cup of coffee. Their goal was to use readily available industrial thermoplastics to help manage the overall product cost. ■ The thermal load analysis and design optimization features of ANSYS were just the answer. The SAEC/Kinetic Vision engineers used the ANSYS program's robust capabilities to determine the feasibility of an induction-heated (electric) coffeepot. ■ Conducting structural and thermal studies with ANSYS proved that the new design was possible, using standard engineering-grade thermoplastics. By using readily available materials, production costs were reduced. ■ With its broad range of structural and design analysis features, ANSYS continues to help designers ensure state-of-the-art product development, while minimizing design and manufacturing costs. The versatility of ANSYS makes design innovation possible.



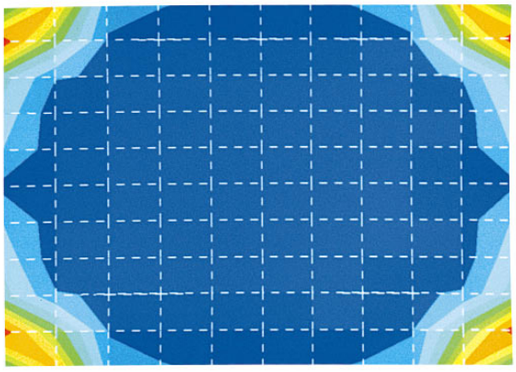
The induction-heated COFFEEPOT.

"A THING OF BEAUTY IS A JOY FOREVER." John Keats, *Endymion*.

SMITHSONIAN INSTITUTION PAINTING



Entering a museum and seeing the breathtaking exquisiteness of paintings by da Vinci, Rubens, Dürer, Seurat, and other great masters wouldn't be possible without the careful attention of art conservators. One area that deserves close attention is transportation. Handling the crucial concerns of transportation includes the preparation for exposure to humidity, vibration, and temperature; as well as the possibility of irreversible harm from the shock of dropping a masterpiece. However, many art lovers wouldn't have the pleasure of seeing these great works without the willingness of museums to share their collections. ■ Before museums loan such paintings, scientific investigation of the potential risks can help mitigate the apprehension surrounding the transporting of valuable artwork. And these studies are absolutely necessary to determine the long-term effects of environment on centuries-old works of art. Understandably, few conservators are willing to submit such precious treasures to actual testing. ■ So, to avoid testing the actual pieces, the Smithsonian Institution turned to ANSYS. Marion Mecklenburg, painting conservator and structural engineer with the Conservation Analytical Laboratory (CAL) in the Smithsonian Institution, explains, "We can be quite specific in defining the strength, stiffness, and flexibility of these materials. So specific, in fact, that these properties can be quantified by mathematical equations and calculated by computer." ■ Mecklenburg has a high degree of confidence in the ANSYS simulation: "The margin of error between the computer modeling and tests done with the actual paintings is very small." ■ After subjecting a model to varying temperature, humidity, and vibration to simulate a variety of transport conditions; the paintings were determined to actually be quite strong within reasonable limits. Surprisingly, vibration, having long been a major concern of modern conservators, really does not have a serious impact. ■ The ANSYS model has demonstrated that it's possible to protect paintings through the use of modern shipping techniques and "virtually guarantee a safe journey for works of arts." For art lovers, it's reassuring to know that the application of ANSYS has helped to ensure the safety of these irreplaceable treasures.

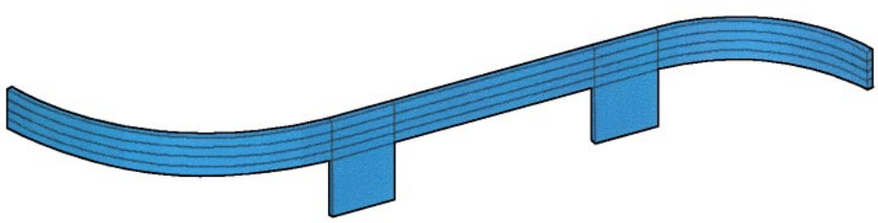


Thermal stress in a PAINTING.

"IF IT WEREN'T FOR ART, THERE WOULDN'T BE ANY SCIENCE."

"FISICROMIA" SCULPTURE

An artist's ability to combine visual cues and juxtapose color and light, as well as redefine shapes, often surprises us. Sculptors work with the added elements of mass, size, and dimension to often create works of huge proportions. The sheer size of many sculptures invites the viewer to move through, around, and even under them—to interact with the art and to be pleasantly surprised by a different perspective from each point of view. Each vantage point offers a new visual experience. ■ Carlos Cruz Diez's work, "Fisicromia," located in Juan Carlos I Park, Campo de las Naciones, is such a sculpture. The Fisicromia is an undulating wall of colored steel fringe that invites visitors to walk around and beneath it. The play of light across the colored steel strips creates an ever-changing landscape for visitors to enjoy. ■ One end of Fisicromia juts out from the horizon and offers a startling view from the crossroads of the park. Essentially a wall of steel beams, it rises high above the land. Anchored only by two concrete pillars, it seems to defy gravity. ■ In reality, it is quite the contrary. The illusion of the sculpture's gravity-defying balance is the result of a collaboration between artistic and engineering skill. ■ To ensure the stability of the sculpture and the structural integrity of the supports under various stresses of weight and wind, engineers applied ANSYS. A model was used to verify the structure's performance in high winds. ■ The ANSYS analysis proved that Fisicromia would withstand the high winds at the park and, therefore, ensure the safety of spectators. The engineers of Ingeciber S.A., in partnership with Cruz Diez, were able to solve a design problem and create a work of art for park visitors to enjoy for many years to come. ■ In Spain, ANSYS helped bridge the gap between imagination and reality.

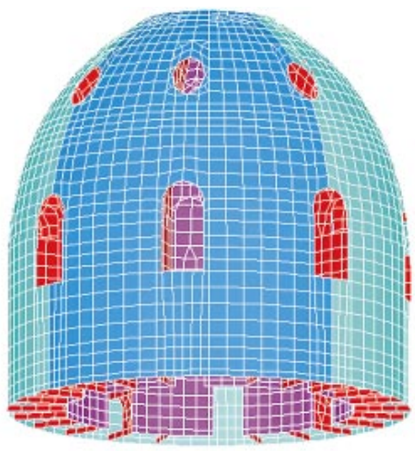


The "FISICROMIA" SCULPTURE.

"WAR IS THE SCIENCE OF DESTRUCTION." John S.C. Abbott.

CHURCH OF OUR LADY IN DRESDEN

The City of Dresden, Germany, is enriched with beautiful baroque and rococo architecture dating from the 17th and 18th centuries. Coupled with a vast collection of Italian, Dutch, and Flemish art treasures, it often is called the German Florence. However, much of this legendary architecture, including the Church of Our Lady in Dresden, was tragically destroyed in the Allied air raids of February, 1945 (during World War II). As a result of the bombings, the church with her marvelous bell-shaped cupola that towered above the roof of the historic center was lost. ■ Recently, planners have begun to restore the Church of Our Lady in Dresden and other architectural landmarks. Because of the church's historical significance and its atypical construction material (sandstone), engineers had to make sure the cupola could withstand its own weight, as well as other loads. ■ Dr.-Eng. Wolfram Jäger of the Planning and Engineering Office for Construction in Dresden began an analysis of a model of the dome. But, needing a more modern method than static testing and detailed proof of the soundness of the planned dome architecture, engineers at the planning office chose ANSYS. The analysis pinpointed the various stress areas which would occur tangentially and circumferentually. ■ ANSYS was able to provide the proof the engineers needed to obtain authorization for reconstruction. It is rewarding to know that, because of ANSYS, a major historic architectural landmark will be restored to its former beauty.



The DRESDEN CHURCH cupola.

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