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Волгоградский государственный архитектурно-строительный университет

СТРОИТЕЛЬНЫЕ КОНСТРУКЦИИ

BUILDING CONSTRUCTIONS

Учебное пособие

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Содержатся аутентичные неадаптированные тексты, посвященные новым тенденциям в области строительства, способствующие выработке у студентов умений и навыков чтения и перевода научно-технической литературы по изучаемой специальности, а также говорения на английском языке в сфере профессиональной коммуникации.

Для студентов 2-го курса строительных и архитектурных специальностей, аспирантов, соискателей.

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Part 1

1. IMPORTANCE OF FRP RETROFIT FOR REINFORCED CONCRETE STRUCTURES

A large number of reinforced concrete bridges in the U.S. are structurally deficient by today's standards. The main contributing factors are changes in the use in load requirements, or corrosion deterioration due to exposure to an aggressive environment. In order to preserve those bridges, rehabilitation is often considered essential to maintain their capability and to increase public safety.

In the last decade, **fiber reinforced polymer (FRP)** composites have been used for strengthening structural members of reinforced concrete bridges. Many researchers have found that FRP composite strengthening is an efficient, reliable, and cost-effective means of rehabilitation. Currently in the U.S., the American Concrete Institute Committee 440 is working to establish design recommendations for FRP application to reinforced concrete.

Figure 1: The Horsetail Creek Bridge

As an example of a bridge classified as structurally deficient is The Horsetail Creek Bridge, built in 1914. It is in use on the Historic Columbia River Highway east of Portland, Oregon. In the following reports subsequent calculations and scientific studies have been made on the example of this bridge.

2. COMPUTER MODELING OF FRP-STRENTHENED STRUCTURES

Typically, the behavior of reinforced concrete beams is studied by full-scale experimental investigators. The results are compared to theoretical calculations that estimate deflections and internal stress/strain distributions within beams. Finite element analysis can also be used to model the behavior numerically to confirm these calculations, as well as to provide valuable supplement to the laboratory investigations, particularly in parametric studies. Finite element dividing it into a number of simple elements, each of which has well-defined mechanical an psychical properties.

Modeling the complex behavior of reinforced concrete, which is both nonhomogeneous and anisotropic, is difficult challenge in the finite element analysis of civil engineering structures. Most early finite element models of reinforced concrete included the effects of cracking based on pre-defined crack pattern. With this approach, changes in the technology of the models were required as the load increased; therefore, the ease and speed of analysis were limited. A smeared cracking approach was introduced using isoparametric formulations to represent the cracked concrete as an orthotropic material. In the smeared cracking approach, cracking of the concrete occurs when the principal tensile stress exceeds the ultimate tensile strength. The elastic modulus of the material is then assumed to be zero in the direction parallel to the principal tensile stress direction.

Only recently researchers have attempted to simulate the behavior of reinforced concrete strengthened with FRP composites using the finite element method. A number of reinforced concrete beams strengthened with FRP plates are tested in the laboratory. Finite element analysis with the smeared cracking approach is used to simulate the behavior and failure mechanisms of the experimental beams. Comparison between the experimental data and the results from finite element models usually shows good agreement, and the different failure mechanisms, from ductile to brittle, can be simulated. In some cases, like the “The Horsetail Creek Bridge”, the FRP plates are modeled with two-dimensional plate elements in that study, however, the crack patterns of the beams are not predicted by the finite element analysis. The two-dimensional plate elements are surface-like elements, which have no actual thickness. Therefore, stress and strain results at the actual surfaces of the FRP plates estimates by theoretical calculations. In addition, in case with the The Horsetail Creek Bridge, an entire FRP-strengthened reinforced concrete bridge was modeled by finite element analysis. In that study truss elements were used to model the FRP composites. The results of the finite element analysis correlated well with the field test data and indicated that external bonding of FRP laminates to the bridge girders reduced the average maximum deflections at midspan and reinforcing steel stresses by 9% and 11%, respectively.

3. SCOPE OF COMPUTER MODELING

In point of fact, opportunities of the computer modeling open up new horizons in construction using the FRP. Finite element method (FEM) models can be developed to simulate the behavior of four full-size beams from linear through nonlinear response and up to failure, using the ANSYS program.

The ANSYS finite element program, operating on UNIX system, is used to simulate the behavior of the four experimental beams. In general, the constructions and methods can be very similar using other nonlinear FEA programs. Each program, however, has its own nomenclature and specialized elements and analysis procedures that need to be used properly. The designer/analyst must be thoroughly familiar with the finite element tools being used, and must progress from simpler to more complex problems to gain confidence in the use of new techniques.

In case with the The Horsetail Creek Bridge, comparisons were made for load-stain plots at midspan; firs cracking loads; loads at failure; and crack patterns at failure. The models were subsequently expanded to encompass the linear behavior of the Horsetail Creek Bridge.

4. MODELING FULL-SIZE REINFORCED CONCRETE BEAMS

Four full-size reinforced concrete beams, similar to the transverse beams of the reconstructed structure are fabricated and tested is special laboratories. Each beam has a different strengthening scheme as described below:

Figure 2: #1 – Control Beam; #2 – Flexure Beam; #3 – Shear Beam; #4 – Flexure/Shear Beam

1. A Control Beam with no FRP strengthening.

2. A beam with unidirectional CFRP laminates attached to the bottom of the beam. The fibers are oriented along the length of the beam. This beam is referred to as Flexure Beam.

3. A beam with unidirectional GFRP laminates wrapped around the sides and the bottom of the beam. The direction of the fibers id perpendicular to the length of the beam. This beam is referred to as a Shear Beam.

4. A beam with both CFRP & GFRP laminates as in the Flexure and Shear Beams. This type of FRP strengthening is used on the transverse beams of the structure. The beam is referred to as the Flexure/Shear Beam.

Strain gauges are attached throughout the beams to record the structural behavior under load: at the top and bottom fibers of the concrete at the middle of the span; on the sides of the beams in high shear region; on the reinforcing bars; and the FRP laminates. Midspan deflection is measured throughout the loading.

Finally crack patterns obtained from the finite element analysis are compared to those observed for the experimental beams.

5. MATERIAL PROPERTIES OF CONCRETE FOR FRP STRUCTURES

Development of the model for the behavior of concrete is a challenging task. Concrete is a quasibrittle material and has different behavior in compression and tension. The tensile strength of concrete is typically 8-15% of the compressive strength. Figure 3 shows a typical stress-strain curve for normal weight concrete.

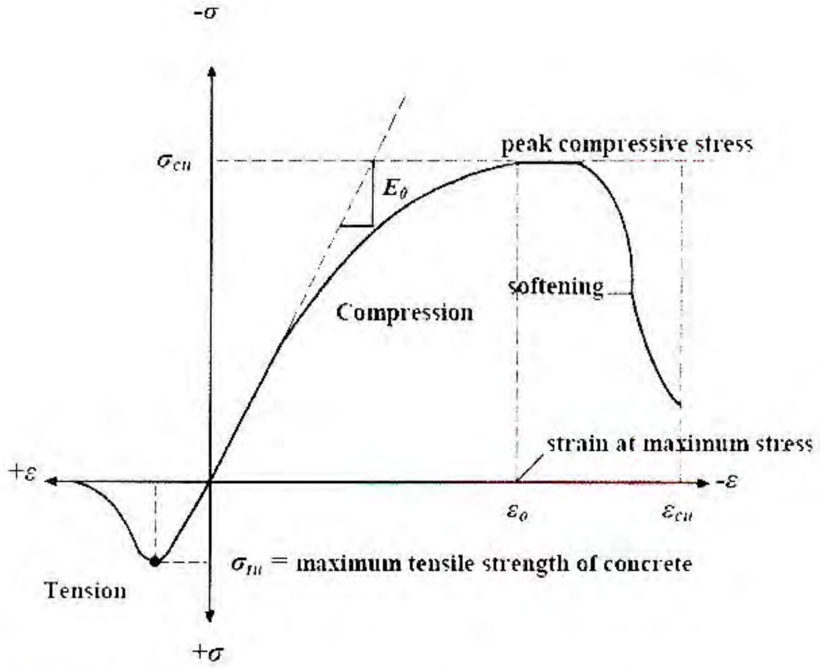

Figure 3 : Typical uniaxial compressive and tensile stress-strain curve for concrete (*Bangash 1989*)

In compression, the stress-strain curve for concrete in linearly elastic up to about 30% of the maximum compressive strength. Above this point, the stress increases gradually up to the maximum compressive strength. After it reaches the maximum compressive strength (f_c\`), the curve descends in a softening region, and eventually crushing failure occurs at an ultimate strain (f_r). In tension, the stress-strain curve for concrete is approximately linearly elastic up to the maximum tensile strength. After this point, the concrete cracks and the strength decreases gradually to zero.

6. STEEL REINFORCEMENT AND STEEL PLATES

Steel reinforcement in the experimental beams is constructed with typical Grade 60 steel reinforcing bars. Properties, i.e., elastic modulus and yield stress, for the steel reinforcement used in this FEM study follow the design material properties used for external investigation. The steel for the finite element models is assumed to be an elastic-perfectly plastic material and identical in tension of compression. Usually, Poisson's ratio of 0,3 is used for the steel reinforcement.

Figure 4 shows the stress-strain relationship. Material properties for the steel reinforcement for all models as the standard are follows:

Elastic modulus, E_s=200,000 MPa (29,000 ksi)

Yield stress, f_y=410 MPa (60,000 psi)

Poisson's ratio, v=0,3

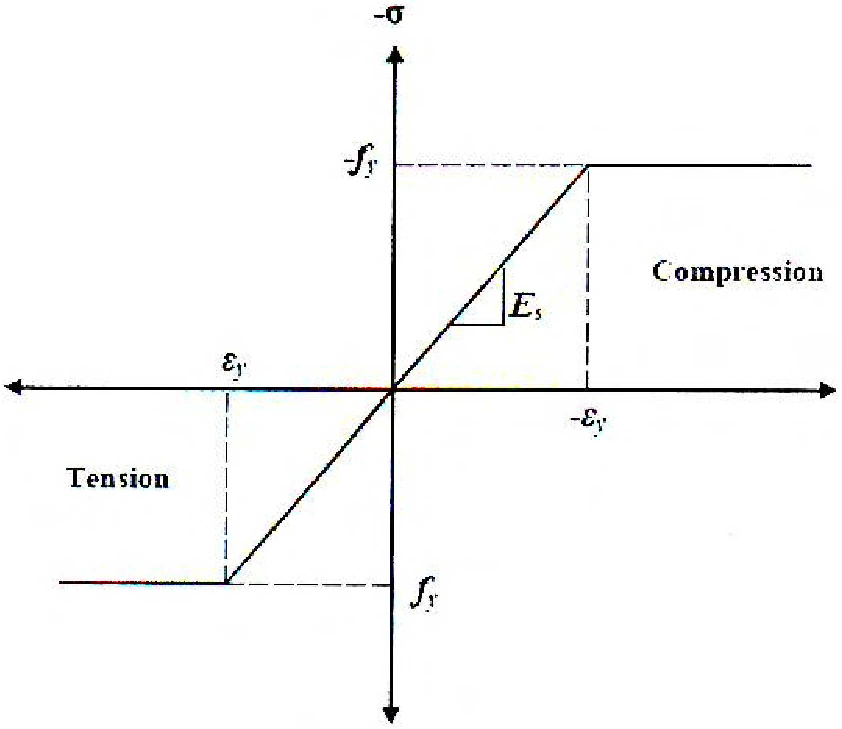

Figure 4 : Stress-strain curve for steel reinforcement

Steel plates are added at support locations in the finite element models (as in the actual beams) to provide a more even stress distribution over the support areas. An elastic modulus equal to 200,000 MPa (29,000 ksi) and Poisson's ratio of 0,3 are used for the plates. The steel plates are assumed to be linear elastic materials.

7. FRP COMPOSITES

FRP composites are materials that consist of two consumers. The constituents are combined at a macroscopic level and are not soluble in each other. One constituent is the reinforcement, which is embedded in the second constituent, a continuous polymer called the matrix. The reinforcing material is in the form of fibers, i.e., carbon and glass, which are typically stiffer and stronger than matrix. The FRP composites are anisotropic materials; that is, their properties are not the same in all directions. Figure 5 shows a schematic of FRP composites.

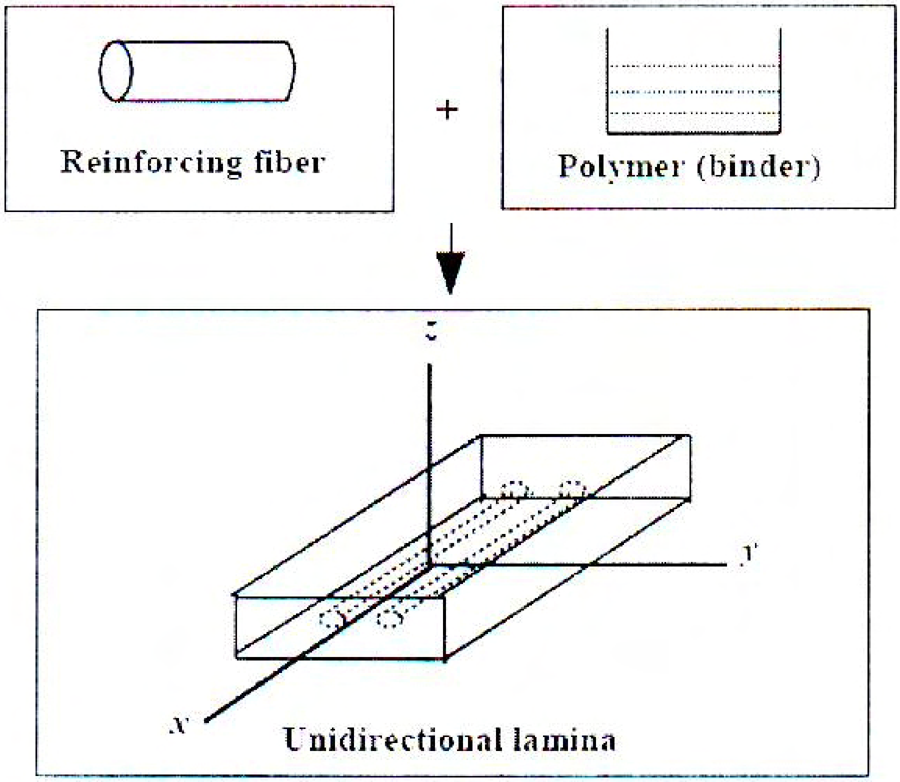

Figure 5 : Schematic of FRP composites (*Gibson 1994, Kaw 1997*)

As shown in the Figure 5, the unidirectional lamina has three mutually orthogonal planes of material properties (i.e., *xy*, *xz*, and *yz* planes). In case with the The Horsetail Creek Bridge, the specially orthotropic material is also transversely isotropic, where the properties of the FRP composites are nearly the same in any direction perpendicular to the fibers. Thus, the properties in the *y* direction are the same as those in the *z* direction.

Glass fiber reinforced polymer was used for shear reinforcement on the Horsetail Falls Bridge because of its superior strain at failure. Carbon fiber reinforced polymer was used for flexural reinforcement because of its high tensile strength. Linear elastic properties of the FRP composites were assumed throughout the work on project of Horsetail Creek Bridge. Figure 6 shows the stress-strain curves for the FRP composites in direction of the fiber.

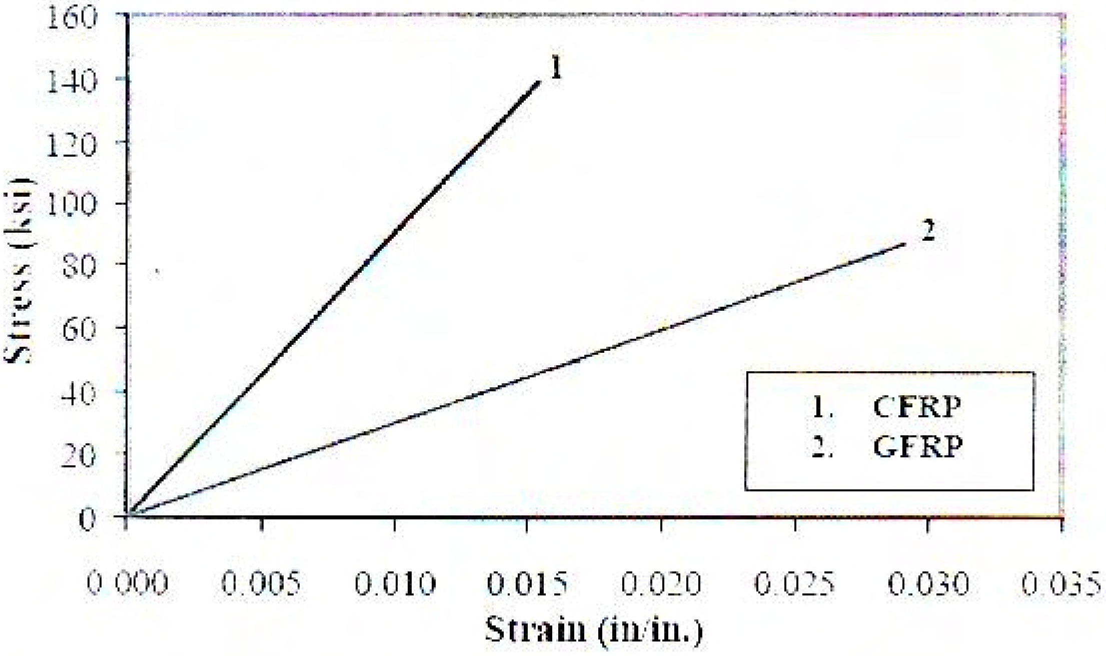

Figure 6 : Stress-strain curves for the FRP composites in the direction of the fibers

Input data needed for the FRP composites in the finite element models are as follows:

- Number of layers;
- Thickness of each layer;
- Orientation of the fiber direction for each slayer;
- Elastic modulus of the FRP composite in three directions;
- Shear modulus of the FRP composite for three planes;
- Major Poisson’s ratio for three planes.

A local coordinate system for the FRP layered solid elements is always defined where the *x* direction is the same as the fiber direction, while the *y* and *z* directions are perpendicular to the *x* direction.

The properties of isotropic materials, such as elastic modulus and Poisson’s ratio, are identical in all directions; therefore no subscripts are required.

All of the modeling and the rest researches are made in the ANSYS program.

8. GEOMETRY OF FRP

Figure 7 illustrates typical dimensions for all standard beams before FRP reinforcing. By taking advantage of symmetry of the beams, a quarter of the full beam is used for modeling. This approach reduces computational time and computer disk space requirements significantly. The quarter of the entire model is shown in Figure 8.

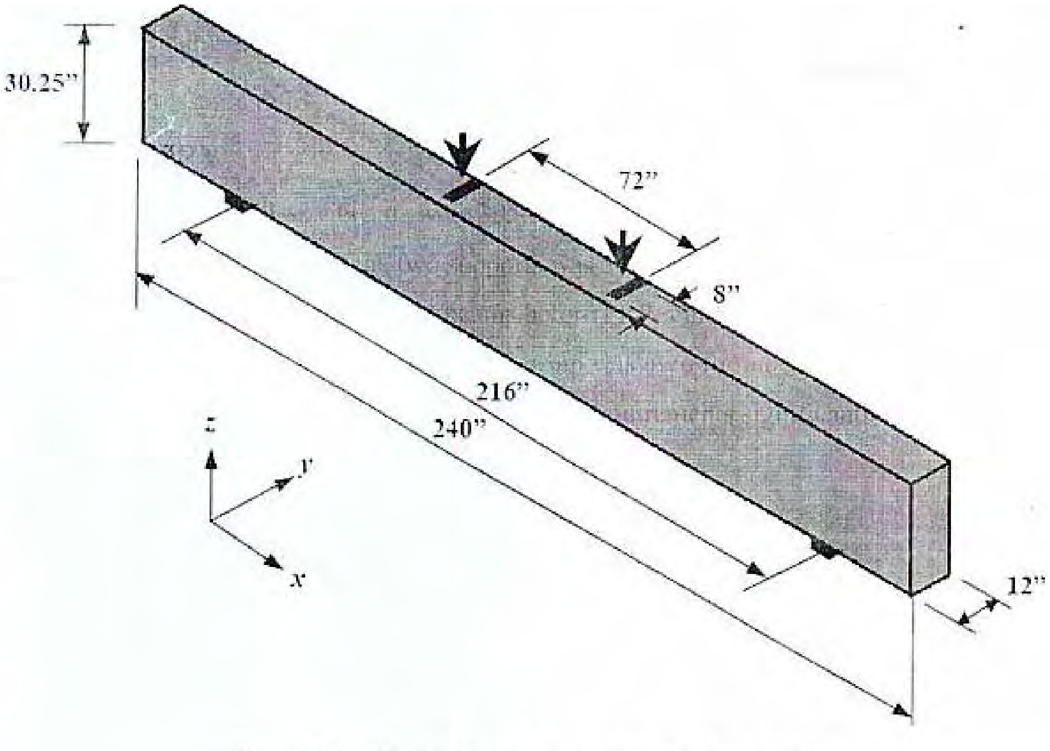

Figure 7 : Typical beam dimensions (not to scale)

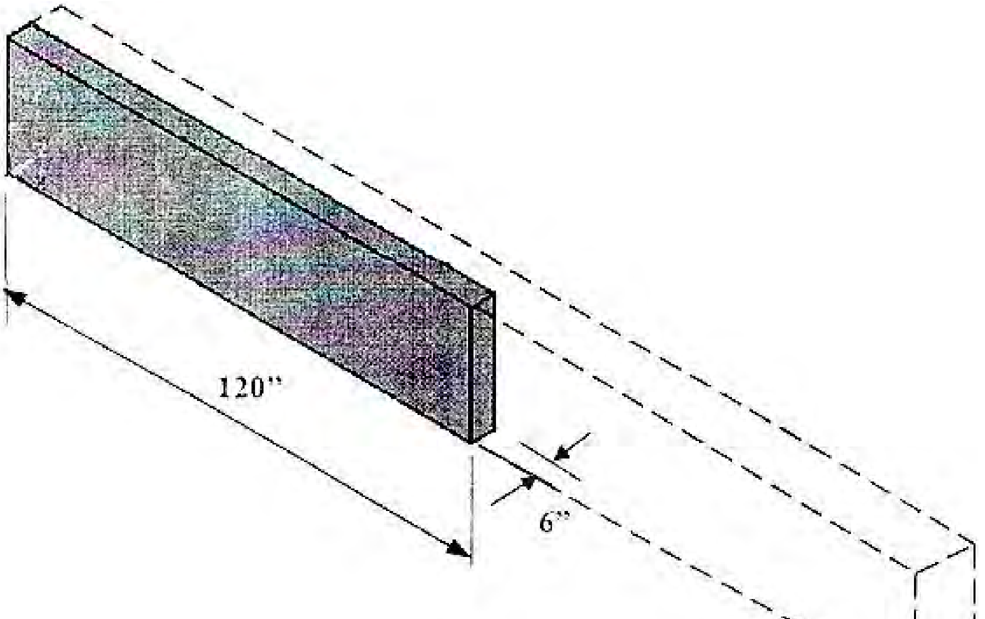

Figure 8 : Use of a quarter beam model (not to scale)

In the finite element models, layered solid elements are used to model the FRP composites. Nodes of the FRP layered solid elements are connected to those of adjacent concrete solid elements in order of satisfy the perfect bond assumption. Figure 9 illustrates the element connectivity.

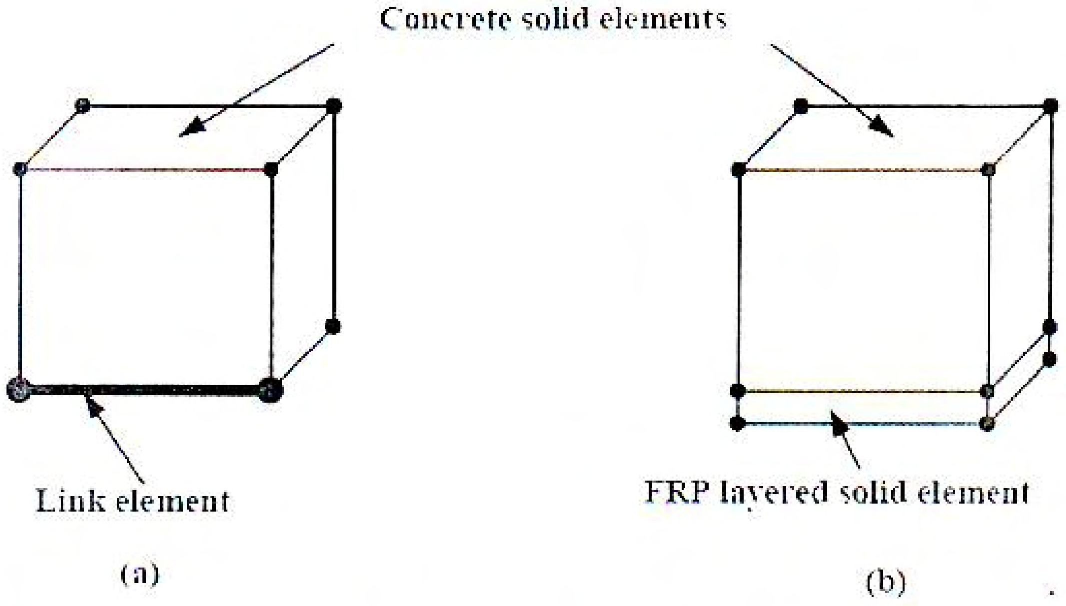

Figure 9 : Element connectivity: (a) concrete solid and link elements: (b) concrete solid and FRP layered solid elements

The various thicknesses of the FRP composites create discontinuities, which are not desirable for the finite element analysis. These may develop high stress concentrations at local areas on the models; consequently, when the model is run, the solution may have difficulties in convergence. Therefore, a consistent overall thickness of FRP composite is used in models to avoid discontinuities. The equivalent overall stiffness of the FRP materials is maintained by making compensating changes in the elastic and shear moduli assigned to each FRP layer.

9. FINITE ELEMENT DISCRETIZATION

As an initial step, a finite element analysis requires meshing of the model. In other words, the model is divided into a number of small elements, and after loading, stress and strain are calculated at integration points of these small elements. An important step in finite element modeling is the selection of the mesh density. A convergence of results is obtained when an adequate number of elements is used in a model. This is practically achieved when an increase in the mesh density has a negligible effect on the results.

At this stage complete full-size beams are modeled. And the diagrams are made to show comparisons between two or more programs, ANSYS and SAP2000 for example. And in the case of The Horsetail Creek Bridge these two programs gave very similar results according on the researches.

Part 2

10. POLISHING (METALWORKING)

Polishing and buffing are finishing processes for smoothing a workpiece's surface using an abrasive and a work wheel. Technically polishing refers to processes that use an abrasive that is glue to work wheel, while buffing uses a loose abrasive applied to the work wheel. Polishing is a more aggressive process while buffing is less harsh, which leads to a smoother, brighter finish. A common misconception is that a polished surface has a mirror bright finish, however most mirror bright finishes are actually buffed.

Polishing is often used to enhance the looks of an item, prevent contamination of medical instruments, remove oxidation, create a reflective surface, or prevent corrosion in pipes. In metallography and metallurgy, polishing is used to create a flat, defect-free surface for examination of a metal's microstructure under a microscope. Silicon-based polishing pads or a diamond solution can be used in the polishing process.

The removal of oxidization (tarnish) from metal objects is accomplished using a metal polish or tarnish remover; this is also called polishing. To prevent further unwanted oxidization, polished metal surfaces may be coated with a wax, oil or lacquer. This is of particular concern for copper alloy products such as brass and bronze.

11. POLISHING PROCESS

Polishing is usually multistage process because the first stage is starts with a rough abrasive and each subsequent stage uses a finer abrasive until the desired finish is achieved. The rough pass removes surface defects like pits, nicks, lines and scratches. The finer abrasives leave very thin lines that are not visible to the naked eye. Lubricants like wax and kerosene are used as lubricating and cooling media during these operations. Buffing may be done by hand with a stationary polisher or die grinder, or it may be automated using specialized equipment.

When buffing there are two types of buffing motions: the cut motion and the color motion. The cut motion is designed to give a uniform, smooth, semi-bright surface finish. This is achieved by moving the workpiece against the rotation of the buffing wheel, while using medium to hard pressure. The color motion gives a clean, bright, shiny surface finish. This is achieved by moving the workpiece with the rotation of the buffing wheel, while using medium to light pressure.

When polishing brass, there are often minute marks in the metal caused by impurities. To overcome this, the surface is polished with a very fine (600) grit, copper plated, then buffed to a mirror finish with an airflow mop.

Polishing operations for items such as chisels, hammers, screwdrivers, wrenches, etc., are given a fine finish but not plated. In order to achieve this finish four operations are required: roughing, dry fining, greasing, and coloring. Note that roughing is usually done on a solid grinding wheel and for an extra fine polish the greasing operation may be broken up into two operations: rough greasing and fine greasing. However, for inexpensive items money is saved by only performing the first two operations.

Polishing knives and cutlery is known as fine glazing or blue glazing. Sand buffing, when used on German silver, white metal, etc., is technically a buffing operation because it uses a loose abrasive, but removes a significant amount of material, like polishing.

12. POLISHING EQUIPMENT

Aluminium oxide abrasives are used on high tensile strength metals, such as carbon and alloy steel, tough iron, and nonferrous alloys. Silicon carbide abrasives are used on hard and brittle substances, such as grey iron and cemented carbide, and low tensile strength metals, such as brass, aluminium, and copper.

Polishing wheels come in a wide variety of types to fulfill a wide range of needs. The most common materials used for polishing wheels are wood, leather, canvas, cotton cloth, plastic, felt, paper, sheepskin, impregnated rubber, canvas composition, and wool; leather and canvas are the most common. Wooden wheels have emery or other abrasives glued onto them and are used to polish flat surfaces and maintained good edges. There are many types of cloth wheels. Cloth wheels that are cemented together are very hard and used for rough work, whereas other cloth wheels that are sewn and glued together are not as aggressive. There are cloth wheels that are not glued or cemented, instead these are sewed and have metal side plates for support. Solid felt wheels are popular for fine finishes. Hard roughing wheels can be made by cementing together strawboard paper disks. Softer paper wheels are made from felt paper. Most wheels are run at approximately 7500 surface feet per minute (SFPM), however muslin, felt and leather wheels are usually run at 4000 SFPM.

Buffing wheels, also known as mops, are either made from cotton or wool cloth and come bleached or unbleached. Specific types include: sisal, spiral sewn, loose cotton, canton flannel, domet flannel, denim, treated spiral sewn, cushion, treated vented, untreated vented, string buff, finger buff, finger buff, sisal rope, mushroom, facer, tampered, scrubbing mushroom, hourglass buff, rag, "B", climax, swansdown, airflow, coolair, and bullet.

The following chart will help in deciding which wheels and compounds to use when polishing different materials. This chart is a starting point and experienced polishers may vary the materials used to suit different applications.

13. DIAMOND WIRE CUTTING

Diamond wire cutting (DWC) is the process of using wire of various diameters and lengths, impregnated with diamond dust of various sizes to cut through materials. Because of the hardness of diamonds, this cutting technique can cut through almost any material that is softer than the diamond abrasive. DWC is also practical and less expensive than some other cutting techniques, for example, thin diamond wire only costs around 10-20 cents per foot ($0.7/m) in 2005 for 140 to 500 micrometre diameter wire, to manufacture and sells around $1.25 a foot ($4.10/m) or more, compared to solid diamond impregnated blade cutters costing thousands of dollars. Thus a 1000 foot (300 m) spool of diamond wire costs around 200 dollars to manufacture and sells for around $1,250. Selling cost may vary because of wire grade and demand. Other Diamond Wire cutting can use shaped diamond rings threaded through cables. These larger cables are used to cut concrete and other large projects.

Advantages

DWC produces less kerf and wasted materials compared to solid blades (slurry wire may be similar). On very expensive materials, this could save hundreds or thousands of dollars of waste. Unlike slurry saws that use bare wire and contain the cutting material in the cutting fluid, DWC uses only water or some fluid to lubricate, cool the cut, and remove debris. On some materials DWC may not need water or cutting fluid, thus leaving a clean dry cut.

Disadvantages

Using Diamond wire for cutting does have the problem of being less robust (snapping when fatigued, bent, jammed or tangling) than solid cutting blades and possible more dangerous because when the wire breaks and whips, it can cause injury as in the 2007 lawsuit case of a man's arm being tangled and cut. Because of the unique nature of DWC, most saws are expensive and are tailor made to handle Diamond Wire. Commercial saws that utilize solid blades can be augmentented with diamond dust blades and thus may be more economical to operate in some areas. Another problem is when the diamond wire breaks in say, the middle of a 3000 ft (1000 m) reel leaving two 1500 ft (500 m) reels of wire, thus requiring up to twice the saw direction change cycles to do the same cut and wearing out the wire saw and remaining diamond wire quicker. If the diamond wire breaks more towards an end, these shorter pieces (500 feet or less) of wire are practically unusable and are commonly disposed of due to the hundreds of feet required to thread the saw, leaving little wire to use for process cutting. Because the diamond abrasive is mechanically attached to the wire, the wire loses cutting effectiveness after a few cuts because most of the abrasive is worn off the wire. This means that the last cut may take much longer than the first cut making production timing less predictable. From experience, Diamond Wire lasts around six cuts then either breaks in several places or is functionally worn out. This longevity greatly depends on the material cut and the number of slices per cut. Quality control of smaller diameter diamond wire is also greatly affects wire life and getting a bad batch is not unknown.

14. BONDED ABRASIVES

A bonded abrasive is composed of an abrasive material contained within a matrix, although very fine aluminium oxide abrasive may comprise sintered material. This matrix is called a binder and is often a clay, a resin, a glass or a rubber. This mixture of binder and abrasive is typically shaped into blocks, sticks, or wheels. The most usual abrasive used is aluminium oxide. Also common are silicon carbide, tungsten carbide and garnet. Artificial sharpening stones are often a bonded abrasive and are readily available as a two sided block, each side being a different grade of grit.

Grinding wheels are cylinders that are rotated at high speed. While once worked with a foot pedal or hand crank, the introduction of electric motors has made it necessary to construct the wheel to withstand greater radial stress to prevent the wheel flying apart as it spins. Similar issues arise with cutting wheels which are often structurally reinforced with impregnated fibres. High relative speed between abrasive and workpiece often makes necessary the use of a lubricant of some kind. Traditionally they were called coolants as they were used to prevent frictional heat build up which could damage the workpiece (such as ruining the temper of a blade). Some research suggests that the heat transport property of a lubricant is less important when dealing with metals as the metal will quickly conduct heat from the work surface. More important are their effects upon lessening tensile stresses while increasing some compressive stresses and reducing "thermal and mechanical stresses during chip formation".

Various shapes are also used as heads on rotary tools used in precision work, such as scale modelling.

Bonded abrasives need to be trued and dressed after they are used. Dressing is cleaning the waste material (swarf and loose abrasive) from the surface and exposing fresh grit.

Truing is restoring the abrasive to its original surface shape. Wheels and stones tend to wear unevenly, leaving the cutting surface no longer flat (said to be "dished out" if it is meant to be a flat stone) or no longer the same diameter across the cutting face. This will lead to uneven abrasion and other difficulties.

15. RAW MATERIALS OF THE GRINDING INSTRUMENTS

A) The ellectrolyticaly produced corundum is an abrasive material, consisting of the corundum (AI2O3) and a few admixture. The industry produces a few sorts of the electrolyticaly produced corundum, also normal, white, chromous, titanium, zirconium, mono-corundum, spheroidal corundum.

The normal electrolyticaly produced corundum - consists of 95% corundum and a few slag and ferroalloy. Depending on the composition and quantity of the admixtures there are changing in the colour of the normal elektrolyticaly produced corundum (from bright- to dark brown), in the micro-structure and properties

Normal electrolyticaly produced corundum is received by reducing melting in the arc furnaces of the charge, consisting of the bauxite agglomerate, low- ash carbonic material and the steel cutting s cheep. During the melting the admixtures which are containing in the bauxite, reduce and go to ferroalloy, except of the calcium oxide (CaO), which goes almost wholly to the electrolyticaly produced corundum, making the mineral generations, which bring down its quality. Also contents of CaO in the bauxite must to be minimum.

High hardness and mechanical durability of the granules of the normal electrolyticaly produced corundum secure them broad field of use during the material s grinding. Normal electrolyticaly produced corundum owns considerable viscosity, which is necessary during the works with variable loads. For manufacturing of the dressing wheels the}ˉ produce the normal electrolytical produced corundum of the poly- crystalline structure, which owns a high durability. The fit of the crystals of such a material- nearly 50 mkm.

They produce grinding granules and micro- powers of various fit of the normal electrolyticaly produced corundum. They are used for various abrasive instruments.

B) ***White electrolyticaly produced corundum*** - consists of corundum (98-99%) and a few admixture(l-2%) as high- aluminous sodium aluminate and others minerals. They receive white electrolyticaly produced corundum by melting of the aluminium oxide in the arc furnace, as a result y -AI2O3 turns into ***a*** - AI2O3. Melting is produced unbroken with the periodically output to the special iron moulding.

The white electrolyticaly produced corundum of it's chemical and physical structure is more homogeneous as normal. Granules of the white corundum own a high durability and sharp borders, they take root simply into the hard solid metals (nitrated, fireproof), make less heating- up as granules of the otheer sorts of the electrolyticaly produced corundum. Abrasive items made of white corundum differ on their stability, own good self- sharpening and secure high clearness of the processing surface.

They make grinding granules, grinding- and micro- powers of the white electrolyticaly produced corundum.

C) ***Titanium electrolyticaly produced corundum*** is an abrasive material, which is reserved during the melting in the arc furnace. Titanium oxide- nearly 0, 3-1, 0%. Electro-corundum with 2-3% titanium oxide is analogue of the normal electro- corundum of a high quality on it's properties; in this product absents ferroalloysand another harmful admixtures.

Titanium electro-corundum is made as grinding granules and grinding powers for manufacturing of the abrasive instruments, which are used for processing of the carbonic, construction and other formed and unformed steels.

D) ***Chromous electrolytically produced corundum*** is an abrasive material, which is received during the melting in the arc furnace with addition of the chrome oxide to 2%. Thanks to this addition increase it's mechanical solidity and abrasive property of the granules in comparison with the granules of the white electro-corundum.

16. THE PROPERTIES OF THE ABRASIVES INSTRUMENTS

The granularity of the abrasive instruments

Abrasive material reduced to fragments is called ***grinding*** material. The fraction means the totality of the iive granulations in the established interval of the size. The fraction predominated over the mass, не and quantity of the granules is called ***the general.***

The granularity characterize the size of the cutting granules of the general fraction in this instrument. Concerning to a size of granules the grinding instruments are divided into following groups: grinding grain from №200 to №16; grinding powers from №12 to №4; grinding micro-powers from M63 to Ml4; fine grinding micro-powers- from M10 to M5. The grinding grain and powers are received by the screen sizing, micro-powers- by the hindered settling in a liquid. The similarity of the grain composition, which influences essential the granularity of the processing surface, the cutting properties and the solidity of the grinding instruments are characterized of the rated keeping of the general fraction. Also they add to the conventional designation of the granularity the letter code according to this rate keeping: В-high; П-raised; Н-nominal; Д-permissible.

Concerning to the group of the materials the granularity is designated in such a way:

- for the grinding grain and grinding powers- 0.1 of the size (mkm) in the side- light of the sieve mesh, where the grains of the general fraction are delayed e.g. 40, 25, 16 (accordingly 400, 250, 160 mkm);
- for the micro-powers - with the top limit of the grain s size of the general fraction with addition of the code letter M, e.g. M40, M28, M10 (accordingly 40, 28, 10 mkm);
- for the diamond grinding powers - the fraction, which numerator corresponds to the size of the top sieve mesh s side, and the denominator- to the size of the low sieve mesh s side of the general fraction e.g. 400/250, 400/315, 160/100, 160/125;
- for the diamond micro- powers and sub- micro- powers- the fraction, which numerator corresponds to a larger and the denominator to a smaller size of the general fraction s grains, e.g.40/28, 28/20, 10/7;
- for the grinding grain and grinding powers in depending of the control s method: the sieve method- 0,1 of the size in the side- light of the sieve mesh, where the grains of the general fraction are delayed e.g. Л20, JT16, Л10; the microscopic method- analogous to the designation of a granularity of the grinding grains and grinding powers, e.g. 250/200, 200/160, 125/100.

The composition, which is demanded in the GOST for the grinding materials 3647-80, in the GOST 9206- for the diamonds powers.

17. THE HARDNESS OF THE ABRASIVE INSTRUMENTS

The notion "the hardness of the abrasive materials" doesn't coincide with the analogous notion, which determines the properties of the metals and other hard substance. The hardness of the grinding instruments characterize the bond s solidity of the abrasive grain s with each other. That is why it is possible to manufacture the mild abrasive instruments of the hard and hard abrasive instruments of the mild. The mild abrasive instruments are called such items, of which the grains fall away easily.

The hardness of the abrasive instruments has an influence upon the cutting properties and border- durability of the abrasive instruments, also upon the term of their wearing property during the cutting process. If the fastening durability of the grains in the abrasive instrument is lower, than the abrasive grain s solidity (a mild abrasive instrument) , the wearing process goes on owing to fall away of the grains and the item works in the regime of the self-sharpening. If the durability of the abrasive grains is lower than of their fastening in the instrument (a hard abrasive instrument), the wearing process goes on partial owing to the grain s shearing and partial to the rubbing-of with the formation of the wearing s areas on the grain.

18. GRINDING

Grinding is a type of machining using an abrasive wheel as the cutting tool. Grinding is considered to be the most accurate of the existing machining processes. A wide variety of machines are used for grinding. They include:

- hand-cranked knife-sharpening stones;
- handheld power tools such as angle grinders and die grinders;
- various kinds of expensive industrial machine tools called grinding machines;
- the bench grinders often found in residential garages and basements.

Grinding practice is a large and diverse area of manufacturing and toolmaking. It can produce very fine finishes and very accurate dimensions; yet in mass production contexts it can also rough out large volumes of metal quite rapidly. It is usually better suited to the machining of very hard materials than is "regular" machining (that is, cutting larger chips with cutting tools such as tool bits or milling cutters), and until recent decades it was the only practical way to machine such materials as hardened steels. Compared to "regular" machining, it is usually better suited to taking very shallow cuts, such as reducing a shaft's diameter by half a thou (equal to 0.001 inch).

Technically, grinding is a subset of cutting, as grinding is a true metalcutting process. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.). However, among people who work in the machining fields, the term *cutting* is often understood to refer to the macroscopic cutting operations, and *grinding* is often mentally categorized as a "separate" process. This is why the terms are usually used in contradistinction in shop-floor practice, even though technically grinding is a subset of cutting.

Similar abrasive cutting processes are lapping and sanding.

Types of grinding processes

Selecting which of the following grinding operations to be used is determined by the size, shape, features and desired production rate.

- **Cylindrical grinding** is also called center-type grinding and is used in the removing the cylindrical surfaces and shoulders of the workpiece. Both the tool and the workpiece are rotated by separate motors and at different speeds. The axes of rotation tool can be adjusted to produce a variety of shapes.
- **Internal grinding** is used to grind the inside diameter of the workpiece. Tapered holes can be ground with the use of internal grinders that can swivel on the horizontal.

Centerless grinding is when the workpiece is supported by a blade instead of by centers or chucks. Two wheels are used. The larger one is used to grind the surface of the workpiece and the smaller wheel is used to regulate the axial movement of the workpiece. Types of centerless grinding include through-feed grinding, in-feed/plunge grinding, and internal centerless grinding.

19. TYPES OF GRINDING PROCESSES

• **Surface grinding** is the most common of the grinding operations. A rotating wheel is used in the grinding of flat surfaces. However, the grinding wheel is not limited to just a cylindrical shape, but can have a myriad of options that are useful in transferring different designs to the object being worked on. When surface grinding an object, one must keep in mind that the shape of the wheel will be transferred to the material of the object like a mirror image. It is common practice to what is called "dress" the stone. So as to make sure the shape of the wheel is what you want. This is done by using a diamond to remove the abrassive material not wanted and to give the desired geometry. Surface grinding is a finishing processes that smoothes the surface of metallic or nonmetallic materials and gives them a more refined look. The surface grinder is comprised of an abrasive wheel, a work- holding device known as a chuck either electromagnetic or vacum, and a reciprocating table. Depending on the material being worked on and the desired surface finish, the wheel's abrasive material can vary from aluminum oxide, silicon carbide, diamond, and cubic boron nitride. The chuck is a device that is used to hold the material in place while it is being worked on. It can do this one of two ways; metallic pieces are held in place by a magnetic chuck, while nonmetallic pieces are vacuumed in place. During the grinding process, the workpiece must be flooded with a coolant to keep it from getting too warm, to act as a lubricant, and also to keep the excess shavings from building up. There are different types of coolants that are used depending on the material that is being worked on; the most common are: water-soluble chemical fluids, water-soluble oils, synthetic oils, and petroleum-based oils. In applying the coolant, care should be taken to apply the liquid directly to the location of the grind. This ensures the coolant reaches the material and is not deflected by the grind wheels high speeds. Typical workpiece materials include cast iron and minor steel. These two materials don't tend to clog the grinding wheel while being processed. Other materials are aluminum, stainless steel, brass and some plastics. The three most important factors to consider when surface grinding are: the material of the grinding wheel, the material of the piece being worked on, and the grinding fluid. Not using the proper grinding fluid can result in the surface finish not being completely smooth. Of course, when grinding at high temperatures, the material tends to become weakened and is more inclined to corrode. This can also result in a loss of magnetism in materials where this is applicable. The tolerances that are normally achieved with grinding are ± 2 x $10'^{4}$inches for a grinding a flat material, and ± 3 x $10'^{4}$inches for a parallel surface. When working with any type of grinder, one should always be cognoscente of safety procedures in order to avoid injury.

Personal safety risks include:

- Rotating workpiece and grinding wheel
- Eye irritation from fine chips
- Eye and skin irritation from cooling fluid
- Grinding wheel disintegration

Environmental safety risks include:

- Disposal of cooling fluid
- Disposal of grinding sludge

Cost elements of surface grinding:

- Time it takes to setup
- Time it takes to unload and load
- Time that the grinder is not in use
- Time it takes to grind the material
- Time it takes to change the tools
- The cost of tools/machinery
- Worker pay
- Sale price of finished product
- Paying for use of tools and equipment

Calculations

- Time to grind = Number of Grind Wheel Passes x the Length of the item to be ground the Feed rate of the material
- Number of Grind Wheel Passes = the Width of ground item (width of grind wheel - the distance the grind wheel Overlaps previous runs) x thickness of the grind depth grind wheel removes per pass

Method for making alpha alumina-based abrasive grain from a dispersion comprising boehmite, wherein the method involves the impregnation of an alpha alumina-based ceramic precursor material. The abrasive grain can be incorporated into abrasive products such as coated abrasives, bonded abrasives, and non-woven abrasives.

What is claimed is:

1. A method for making alpha alumina-based ceramic abrasive grain, said method comprising the steps of : (a) converting a dispersion comprising a mixture comprising a first liquid medium, a peptizing agent, zirconium compound, and greater than 60 percent by weight boehmite, based on the total weight of said dispersion, to alpha alumina-based ceramic precursor material; (b) impregnating the precursor material with an impregnating composition comprising a mixture comprising a second liquid medium and magnesium salt; and (c) converting the impregnated precursor material to alpha alumina- based ceramic abrasive grain, wherein said zirconium compound and said magnesium salt are present in a sufficient amount to provide said abrasive grain with, on a theoretical metal oxide basis, at least 0.1 percent by weight metal oxide, based on the total metal oxide content of said abrasive grain.

2. A method for making alpha alumina-based ceramic abrasive grain, said method comprising the steps of: (a) converting a dispersion comprising a mixture comprising a first liquid medium, a peptizing agent, zirconium compound, magnesium salt, and greater than 60 percent by weight boehmite, based on the total weight of said dispersion, to alpha alumina-based ceramic precursor material; (b) impregnating the precursor material with an impregnating composition comprising

a mixture comprising a second liquid medium and a metal oxide or precursor thereof ; and (c) converting the impregnated precursor material to alpha alumina-based ceramic abrasive grain, wherein said zirconium compound and said metal oxide or precursor thereof are present in a sufficient amount to provide said abrasive grain with, on a theoretical metal oxide basis, at least 0.1 percent by weight metal oxide, based on the total metal oxide content of said abrasive grain.

3. A method for making alpha alumina-based ceramic abrasive grain, said method comprising the steps of : (a) converting a dispersion comprising a mixture comprising water, at least one acid, zirconium compound, and greater than 60 percent by weight boehmite, based on the total weight of said dispersion, to alpha alumina-based ceramic precursor material; (b) extruding said dispersion in the form of a rod; (c) drying the dispersion and calcining the dried dispersion; (d) impregnating the precursor material with an impregnating composition comprising a mixture comprising water and magnesium salt; and (e) converting the impregnated precursor material to alpha alumina- based ceramic abrasive grain, wherein said zirconium compound and said magnesium salt thereof are present in a sufficient amount to provide said abrasive grain that are rod shaped with, on a theoretical metal oxide basis, at least 0.1 percent by weight metal oxide, based on the total metal oxide content of said abrasive grain, and said abrasive grain having a density greater than 92 percent of theoretical.

4. The method according to claim 3, wherein said impregnating material impregnated into said precursor material is sufficient to provide, on a theoretical oxide basis, greater than 0.1 percent metal oxide, based on the total theoretical oxide content of said abrasive grain.

5. A method for making an abrasive article, said method comprising the steps of: (a) converting a dispersion comprising a mixture comprising a first liquid medium, a peptizing agent, zirconium compound, and greater than 60 percent by weight boehmite, based on the total weight of said dispersion, to alpha alumina-based ceramic precursor material; (b) impregnating the precursor material with an impregnating composition comprising a mixture comprising a second liquid medium and magnesium salt; (c) converting the impregnated precursor material to alpha alumina- based ceramic abrasive grain; and (d) combining at least a plurality of said alpha alumina-based ceramic abrasive grain with binder to provide an abrasive article, wherein said zirconium compound and said magnesium salt are present in a sufficient amount to provide said abrasive grain with, on a theoretical metal oxide basis, at least 0.1 percent by weight metal oxide, based on the total metal oxide content of said abrasive grain.

6. A method of making a shaped alpha alumina based ceramic abrasive grain comprising the steps of : (a) preparing a dispersion comprising a first liquid medium, a peptizing agent, and an alumina source that is capable of converting to alpha alumina; (b) extruding the dispersion in the form of a rod; (c) cutting the dispersion to form an article; (d) converting the article into a ceramic precursor material; and (e) sintering the ceramic precursor material to form an abrasive grain

having a relatively uniform cross-sectional area and an aspect ratio less than about one.

7. A method of making a shaped alpha alumina based ceramic abrasive grain comprising the steps of : (a) preparing a dispersion comprising a first liquid medium, a peptizing agent, and a greater than 35 percent by weight boehmite; (b) extruding the dispersion in the form of a rod; (c) cutting the dispersion to form an article; (d) converting the article into a ceramic precursor material; and (e) sintering the ceramic precursor material to form an abrasive grain having a relatively uniform cross-sectional area and an aspect ratio less than about one.

8. The method of any one of claims 6 or 7, wherein the dispersion comprises a nucleating agent.

9. The method of any one of claims 6 or 7, wherein the aspect ratio of the abrasive grain is less than about 0.5.

10. A bonded abrasive comprising an abrasive coating that includes abrasive grains produced from any one of claims 1,2,3,4,5,6, or 7 and a binder.

11. The bonded abrasive of claim 10 as a component of an abrasive article selected from the group consisting of a coated abrasive article, cut-off wheels, grinding wheels, honing stones, polishing sticks, saw blades, cutting sticks, mounted points, snagging wheels, dressing tools, cup wheels, depressed center wheels, and flap wheels.

12. A bonded abrasive according to claim 11, wherein the binder is selected from the group consisting of an organic binder, a metal binder, and a vitrified binder.

20. SELECTING THE BEST GRINDING WHEEL

FOR A JOB COMPELS A SHOP TO MATCH the characteristics of the wheel's basic components — its abrasive and its bonding system — with the requirements of the application. Bonded abrasives, such as those in grinding wheels, are made up of grains that are held together by a fixative material. Coated abrasives, such as used in belt, disc, roll, sheet, and flap-wheel products, consist of abrasive grains that are built onto a cloth or paper backing. The classification of abrasives and bond materials and their basic characteristics is rather straight-forward. However, manufacturers incorporate many proprietary additives and fillers that give these materials unique characteristics that must be considered when matching application performance and finish requirements. Families of abrasive formulations include aluminum oxides, silicon carbides, ceramic grain abrasives and the superabrasives — diamond and cubic boron nitride (CBN).

Aluminum oxides

Aluminum oxide consists of blunt shaped grains and is very tough in its lowest refined form. During the melting stage in the production of aluminum oxide, the crystalline structure and its chemistry can be controlled, allowing the manufacturer to produce a family of products that perform differently. Aluminum oxide is produced in a variety of types, and its versatility makes it the most commonly used abrasive.

White fused aluminum oxide is softer, or more friable, than other abrasives. It has high chemical purity (more than 99 percent Al_2O_3) that gives it an aggressive, cool, fast-cutting action. White-fused aluminum oxide holds its form well. It is used to grind heat-sensitive alloys. These applications make use of its friability and the fact that it cuts without generating high heat. This grain is also used to gring heat treated tool steels, high speed steels, and for internal grinding wheels.

Aluminum oxide fused with chrome oxide is a pink abrasive that is used in grinding applications that require slightly more toughness than white fused aluminum oxide. The chrome oxide component of the abrasive enhances its grinding capacity. Although friable and cool cutting, aluminum oxide fused with chrome oxide exhibits strong form-holding characteristics. It is used for precision, broad surface and toolroom grinding on hard alloy steels.

Brown fused aluminum oxide includes 2 to 4 percent titanium oxide (TiO_2) to enhance toughness. (Titanium oxide is also known as titania.) This is the most widely used abrasive, and is used to grind high-tensile-strength materials, and for rough grinding, deburring and snagging, as well as to cut low-alloy, ferrous materials.

Low titania brown fused aluminum oxide has 1 to 2 percent TiO_2 content, and is used in bonded or coated applications that require an abrasive that is slightly tougher than white aluminum oxide. Reducing the titania content reduces the abrasive's toughness, but increases its friability.

21. ABRASIVE

An abrasive is a material, often a mineral, that is used to shape or finish a workpiece through rubbing which leads to part of the workpiece being worn away. While finishing a material often means polishing it to gain a smooth, reflective surface it can also involve roughening as in satin, matte or beaded finishes.

Abrasives are extremely commonplace and are used very extensively in a wide variety of industrial, domestic, and technological applications. This gives rise to a large variation in the physical and chemical composition of abrasives as well as the shape of the abrasive. Common uses for abrasives include grinding, polishing, buffing, honing, cutting, drilling, sharpening, lapping, and sanding. (For simplicity, "mineral" in this article will be used loosely to refer to both minerals and mineral-like substances whether man-made or not.)

Files act by abrasion but are not classed as abrasives as they are a shaped bar of metal. However, diamond files are a form of coated abrasive (as they are metal rods coated with diamond powder).

Abrasives give rise to a form of wound called an abrasion or even an excortation. Abrasions may arise following strong contract with surfaces made things such as concrete, stone, wood, carpet, and roads, though these surfaces are not intended for use as abrasives.

22. MECHANICS OF ABRASION

Abrasives generally rely upon a difference in hardness between the abrasive and the material being worked upon, the abrasive being the harder of the two substances. However, this is not necessary as any two solid materials that repeatedly rub against each other will tend to wear each other away (such as softer shoe soles wearing away wooden or stone steps over decades or centuries or glaciers abrading stone valleys).

Typically, materials used as abrasives are either hard minerals (rated at 7 or above on Mohs scale of mineral hardness) or are synthetic stones, some of which may be chemically and physically identical to naturally occurring minerals but which cannot be called minerals as they did not arise naturally. (While useful for comparative purposes, the Mohs scale is of limited value to materials engineers as it is an arbitrary, ordinal, irregular scale.) Diamond, a common abrasive, for instance occurs both naturally and is industrially produced, as is corundum which occurs naturally but which is nowadays more commonly manufactured from bauxite. However, even softer minerals like calcium carbonate are used as abrasives, such as "polishing agents" in toothpaste.

Grit size ranging from 2 mm (the large grain) (about F 10 using FEPA standarts) to about 40 micrometres (about F 240 or P 360).

These minerals are either crushed or are already of a sufficiently small size (anywhere from macroscopic grains as large as about 2 mm to microscopic grains about 0.001 mm in diameter) to permit their use as an abrasive. These grains, commonly called grit, have rough edges, often terminating in points which will decrease the surface area in contact and increase the localised contact pressure. The abrasive and the material to be worked are brought into contact while in relative motion to each other. Force applied through the grains causes fragments of the worked material to break away while simultaneously smoothing the abrasive grain and/or causing the grain to work loose from the rest of the abrasive.

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