Glass Industry and Recycling

What is Glass???

Glass is an amorphous solid material.

Glass are typically brittle and optically transparent

Glass is a hard material normally fragile and common in our daily life

It is composed mainly of sand and an alkali

Main properties of glass

- **Solid and hard material**
- **Disordered and amorphous structure**
- **Fragile and easily breakable into sharp pieces**
- **Transparent to visible light**
- **One of the safest packaging materials due to its composition and properties**

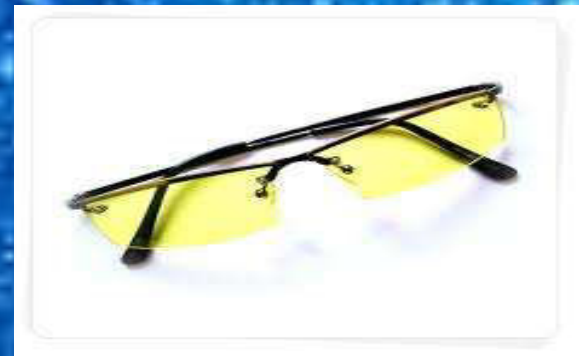
Types of Glass waste

Soda glass or soda-lime glass

Coloured glass

Plate glass

Optical glass



Pyrex glass

Photo-chromatic glass

Lead crystal glass

Safety glass

Laminated glass

What is Glass Recycling???

- **Process of taking old glass products and turning them into new, reusable glass products**
- **Recycling old glass uses 40% less energy than manufacturing it from new**
- **100% recyclable**

Recycling process

- **Collection**
  - First the glass gets collected and is kept separately according to its colour
- **Transportation**
  - Second the glass is transported to the processing plant where contaminants such as metal caps and plastic sleeves are removed
- **Crushing**
  - Third the glass is then crushed into small pieces called cullet. It is now ready to be transported to the glass factory.
- **Mixing**
  - Fourth at the glass factory, the cullet is mixed with other raw materials used to make glass (sand, limestone and soda ash) and melted in a large furnace
- **Melting**
  - The molten glass is moulded into new bottles and jars

Outcomes of Recycling???









Benefits of Recycling???

- **Glass can be recycled over again and never lose its quality or quantity**
- **Creates less air pollution**
- **Reduces water pollution**
- **Saves enough energy to light a 100-watt light bulb for hours**
- **It reduces landfill space**

- **Reduces CO2 emissions**
- **Helps the environment**
- **Cuts waste disposal costs**
- **Increases public awareness of the benefits of recycling**
- **Creates employment**
- **Glass Recycling Pays**

Negatives of Glass Recycling???

- **Manual Labor Costs**

- **Low Availability**

- **Health Hazards**

Future of Glass

- Many new applications and manufacturing processes will involve glass in combination with other materials

- There is an increasing need to combine optical and electronic devices for many applications such as transmission of audio, video and data information

- Glasses and ceramics, either alone or composite with other materials, will find increasing application in biological and medical areas

Thank you

Recycled Crushed Glass and Its Many Uses

Glass is an incredibly versatile material, with the capability to be recycled into many different products. These include fiberglass insulation products and recycled glass countertops. More and more uses are also associated with recycled crushed glass.

Glass for recycling is collected from either the kerbside or recycling centres.After sorting into different colours in most cases, it is processed depending upon the end product. For recycled crushed glass, large crushing and grinding machinery is used to reduce the broken glass into granules of a controlled size. The size of the crushed glass granules will depend upon the useof the crushed glass.

Used in the Production of Concrete

One of the more recent applications for recycled glass granules is in the production of concrete where it is used as an aggregate alongside more traditional sand and gravel products. The glass improves the properties of the concrete especially in terms of thermal insulation where the improved thermal properties of the crushed glass are transferred to the concrete. There is also evidence that the addition of recycled glass granules improves the long-term strength of concrete.

A Blasting Agent

Another application of recycled crushed glass is in the surface finishing industry. The glass provides a much better performance as a blasting agent for metal finishing compared with many products made from slag or minerals. This is due to the angular shape of the particles, which are more effective at removing coatings from metal such as paint, vinyl, epoxy coatings and other elastomers. The range of glass size used varies with the application, from less than 0.2 mm for fine applications to about 2 mm for coarse coating removal.

Used in the Production of Filters

Crushed glass has also been put to good use in the filtration industry. It can be used to produce filters where previously silica sand was used. The suggested size for crushed glass granules in filters is 0.5 to 1 mm, which produces extremely clear filtered water. Applications include filtration for drinking water, swimming pools and industrial use.

Used as a Soft Surface for Play Areas

One of the most interesting aspects of recycled glass granules is that they are not sharp. Although the broken bottles and other items used for the raw material can be exceptionally dangerous to handle and require protective equipment, the granules produced are not sharp. This is due to the nature of the glass crushing and grinding process, which not only reduces the size of the particles to that required, but also takes off all the sharp edges. The glass can, therefore, be used in many places where sand would normally be the first choice. For example, crushed glass has been used to finish children's play areas where it provides a soft surface to cushion the inevitable falls that occur when children are playing.

Used for Bedding Pipes

Recycled crushed glass is also used for bedding pipes. When the pipe is being laid, a layer of glass granules will be spread underneath the pipe to make sure that it is evenly supported along its entire length. After the pipe is completed, it will be buried in the glass, before the earth is backfilled. This reduces the chance of cracks developing in the pipe over the long-term, as the subsoil moves with changes in temperature and moisture content.

Crushed glass is an extremely versatile material with many uses across a broad spectrum of industries. It is used in manufacturing to clean and finish metals and other materials, and in the process industries of filters. It also has applications in civil engineering as an aggregate and substitute for sand as well as being used as a soft surface for play areas. It is a highly versatile material and one of the most widely used recycled materials.

Décor Stone – Decore Crushed Glass
Address:84-90 Highbury Road, Burwood, VIC, 125
Phone Number:(03) 9888 9888
Website:http://www.decorstone.com.au

Glass Fibers

Introduction

- Ancient Egyptians use glass fibers for decorative items in the 16th and 17th century.
- But the use of glass fibers as a reinforcing material is a new idea.
- Continuous glass fibers were first manufactured in substantial quantities by Owens Corning Textile Products in the 1930’s for high temperature electrical applications.

Introduction (cont….)

- Silica is the major constituent of all glass fiber types (more than 50%)
- Other ingredients include the aluminum, calcium and magnesium oxides and borates.

Glass Compositions

- A GLASS – Soda lime silicate glasses used where the strength, durability, and good electrical resistivity of E Glass are not required.
- C GLASS – Calcium borosilicate glasses used for their chemical stability in corrosive acid environments.
- D GLASS – Borosilicate glasses with a low dielectric constant for electrical applications.

Glass Compositions (cont….)

- E-GLASS – Alumina-calcium-borosilicate glasses with a maximum alkali content of 2 wt. % used as general purpose fibers where strength and high electrical resistivity are required.
- ECR-GLASS® – Calcium aluminosilicate glasses with a maximum alkali content of 2 wt. % used where strength, electrical resistivity, and acid corrosion resistance are desired.
- AR-GLASS – Alkali resistant glasses composed of alkali zirconium silicates used in cement substrates and concrete.

Glass Compositions (cont….)

- R-GLASS – Calcium aluminosilicate glasses used for reinforcement where added strength and acid corrosion resistance are required.
- S-2 GLASS® – Magnesium aluminosilicate glasses used for textile substrates or reinforcement in composite structural applications which require high strength, modulus, and stability under extreme temperature and corrosive environments.

Glass Compositions (cont….)

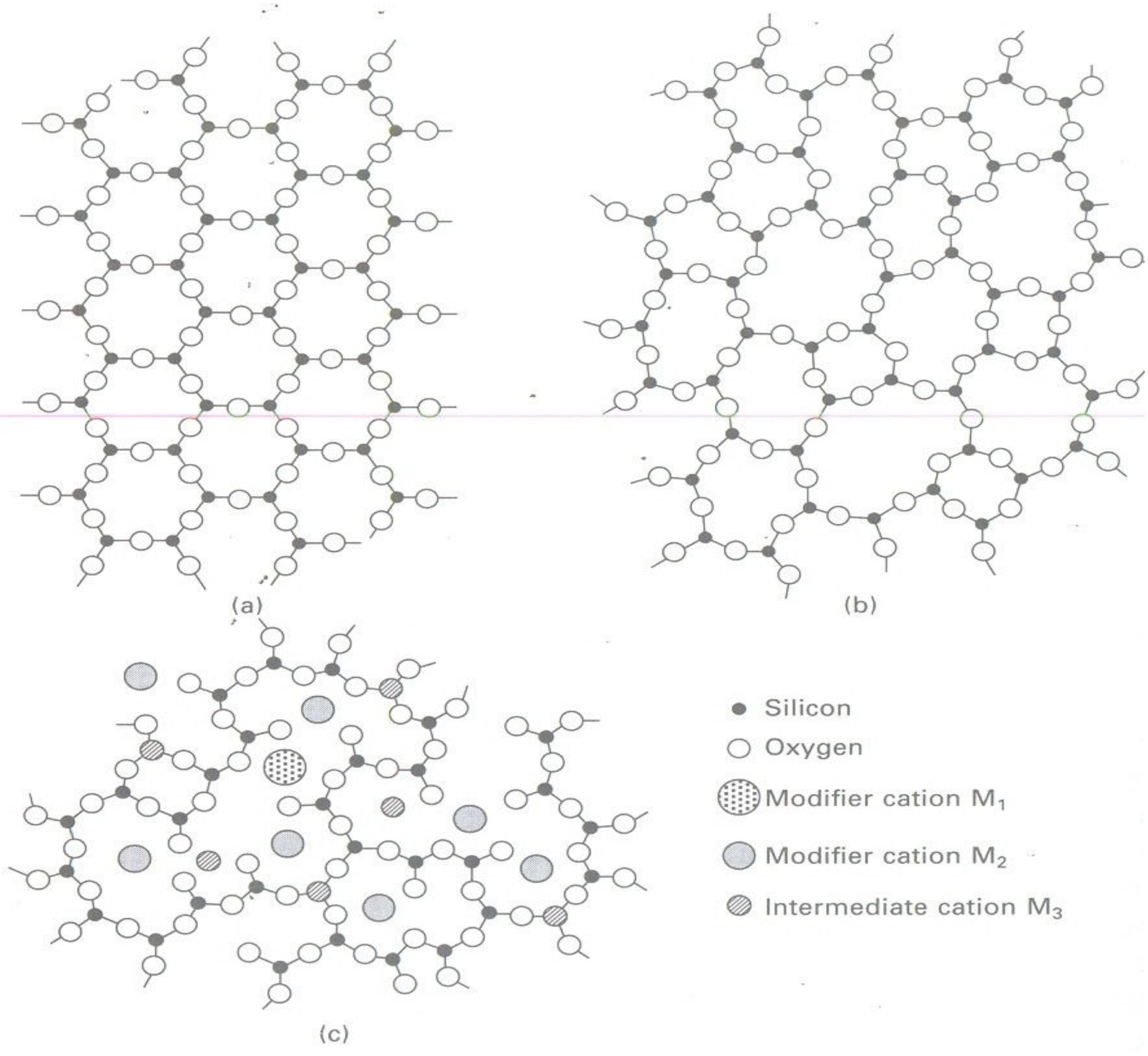
	A GLASS	C GLASS	D GLASS	E GLASS	ECRGlas®	AR GLASS	R GLASS	S-2 GLASS®
Oxide	%	%	%	%	%	%	%	%
SiO_2	63-72	64-68	72-75	52-56	54-62	55-75	55-60	64-66
Al_2O_3	0-6	3-5	0-1	12-16	9-15	0-5	23-28	24-25
B_2O_3	0-6	4-6	21-24	5-10		0-8	0-0.35	
CaO	6-10	11-15	0-1	16-25	17-25	1-10	8-15	0-0.2
MgO	0-4	2-4		0-5	0-4		4-7	9.5-10
ZnO					2-5			
BaO		0-1						
Li_2O						0-1.5		
$Na_2O + K_2O$	14-16	7-10	0-4	0-2	0-2	11-21	0-1	0-0.2
TiO_2	0-0.6			0-1.5	0-4	0-12		
ZrO_2						1-18		
Fe_2O_3	0-0.5	0-0.8	0-0.3	0-0.8	0-0.8	0-5	0-0.5	0-0.1
F_2	0-0.4			0-1		0-5	0-0.3	

Manufacturing Companies

- Owens Corning, Ohio, USA.
- Ventrotex, Europe.
- Ahlstrom, Finland.
- Pilkington, UK.

Glass Fiber Manufacturing

- Glass melts are made by fusing (co-melting) silica with minerals, which contain the oxides needed to form a given composition. The molten mass is rapidly cooled to prevent crystallization and formed into glass fibers by a process also known as fiberization.
- Glass is an inorganic fiber which is neither oriented nor crystalline.



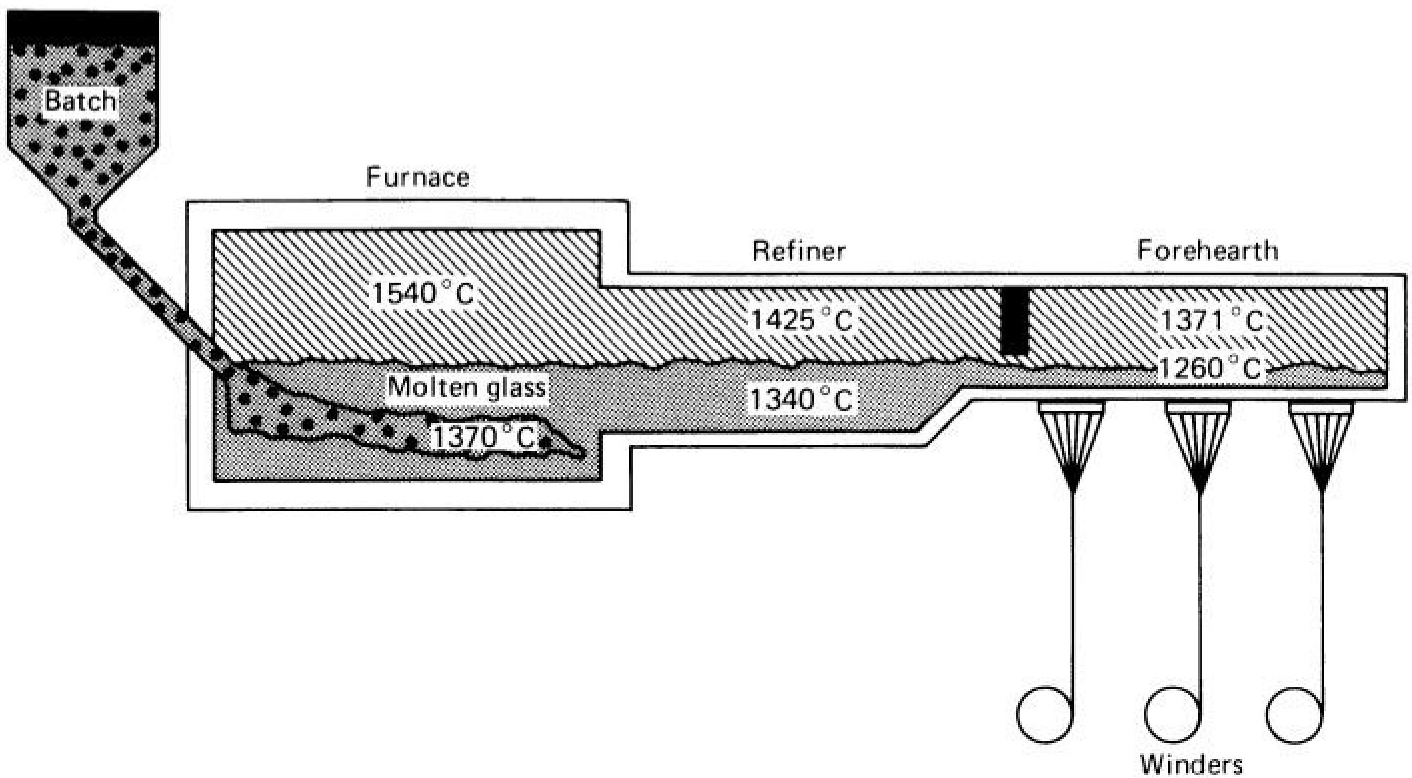
15.2 Two-dimensional schematic representation of (a) a crystalline structure; (b) a simple glass; and (c) a multicomponent glass.

Batch Mixing and Melting

- The glass melting process begins with the weighing and blending of selected raw materials.
- In modern fiberglass plants, this process is highly automated, with computerized weighing units and enclosed material transport systems.
- The individual components are weighed and delivered to a blending station where the batch ingredients are thoroughly mixed before being transported to the furnace.

Batch Mixing and Melting

- Fiberglass furnaces generally are divided into three distinct sections:

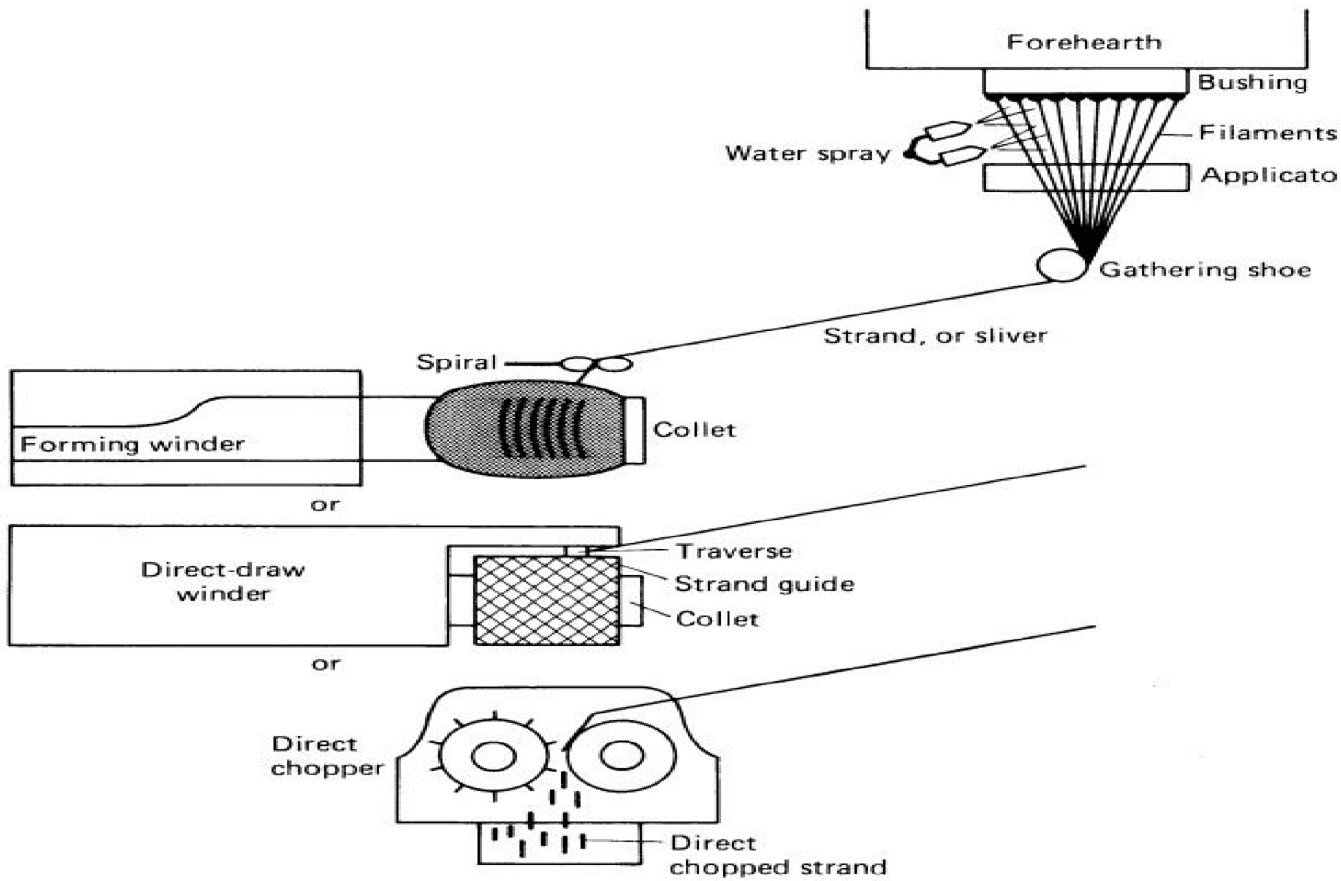


Batch Mixing and Melting

- Batch is delivered into the furnace section for melting at about 1400°C, removal of gaseous inclusions, and homogenization.
- Then, the molten glass flows into the refiner section, where the temperature of the glass is lowered to about 1260°C.
- The molten glass next goes to the forehearth section located directly above the fiber-forming stations.

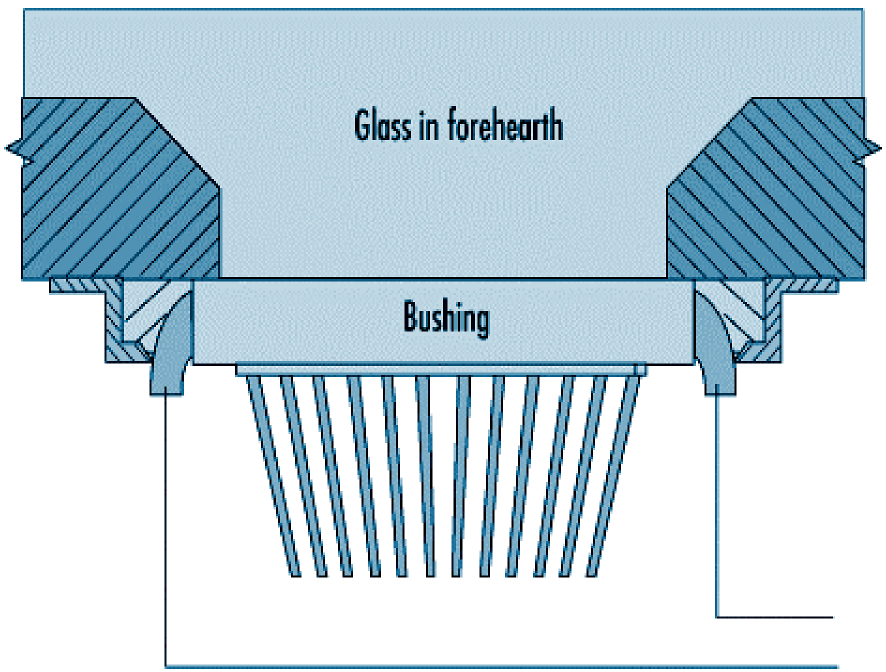
Fiberizing and Sizing

- The conversion of molten glass in the forehearth into continuous glass fibers is basically an attenuation process

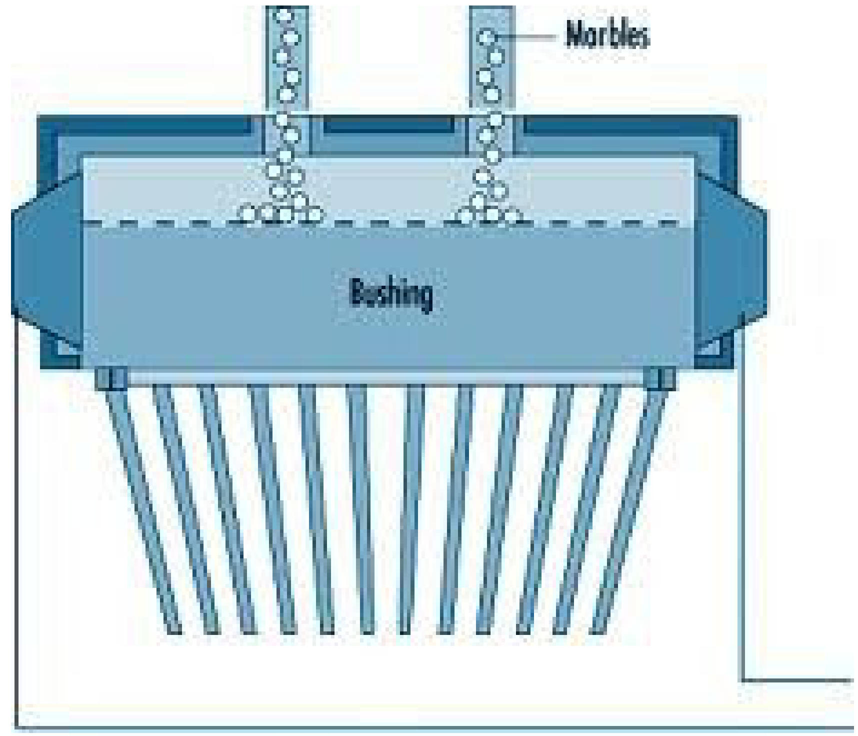


Fiberizing and Sizing

- The molten glass flows through a platinum rhodium alloy bushing with a large number of holes or tips (400 to 8000, in typical production).
- The bushing is heated electrically, and the heat is controlled very precisely to maintain a constant glass viscosity.
- Optimum fiber formation is achieved with melts having a viscosity ranging from 0.4 to 0.5 P.
- The fibers are drawn down and cooled rapidly as they exit the bushing.



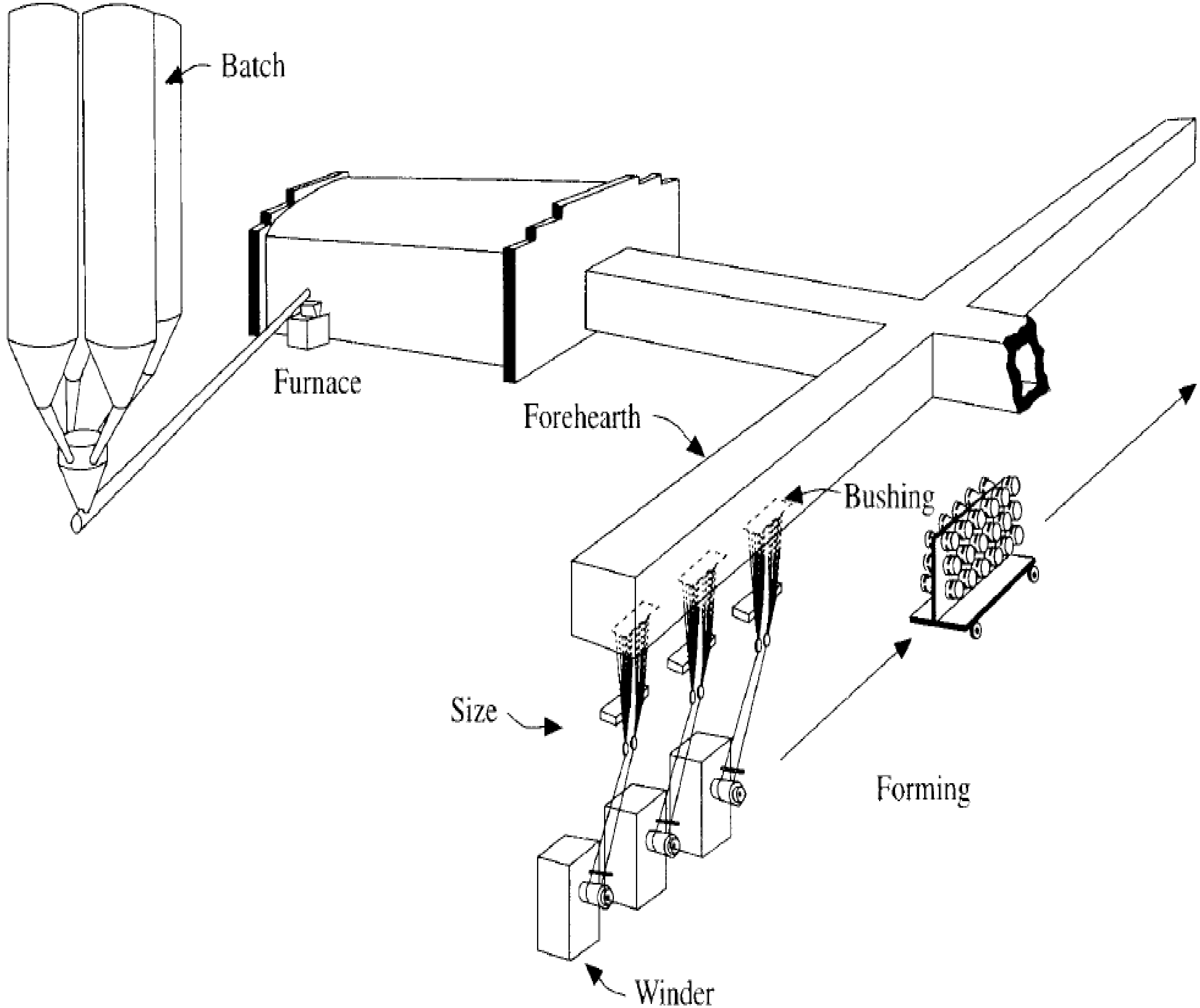
Source: Adapted from Tooley 1974.



Source: Adapted from Tooley 1974.

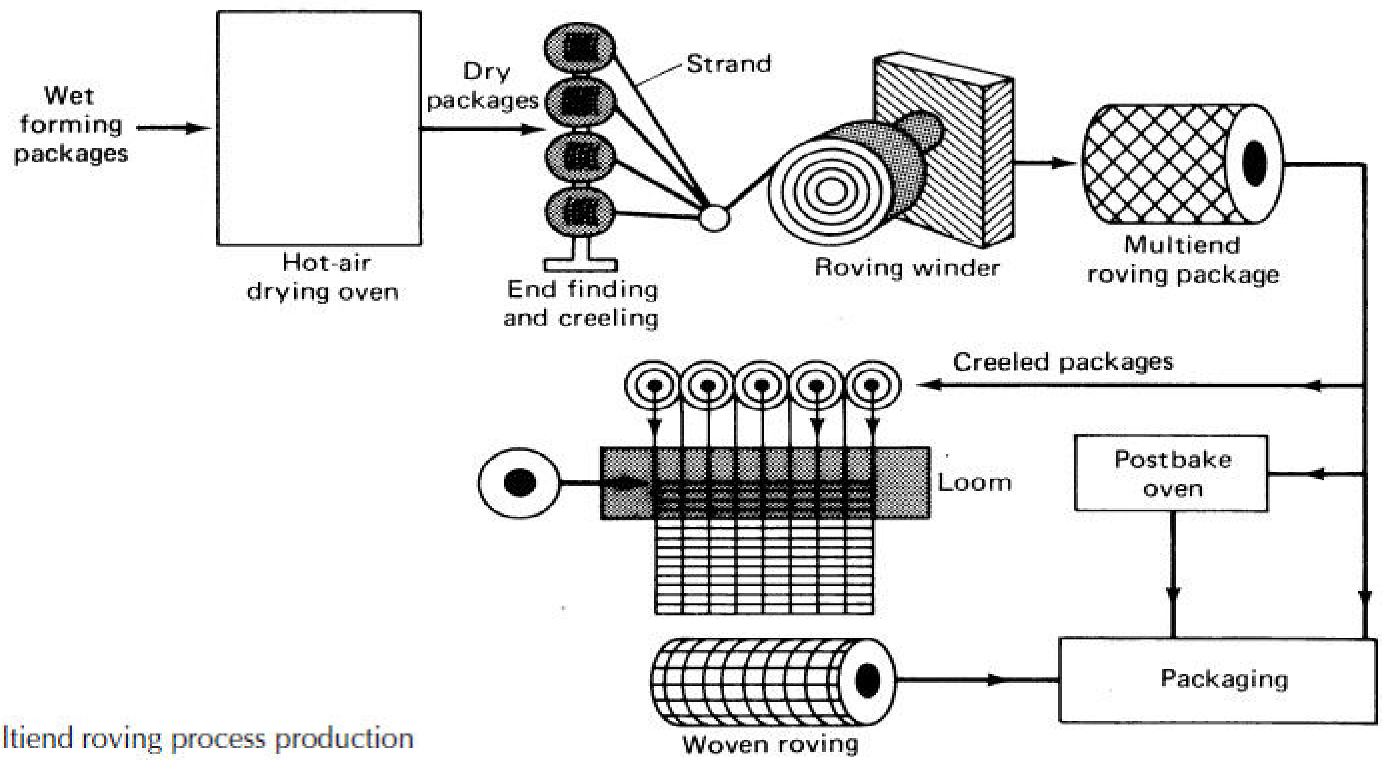
Fiberizing and Sizing

- A sizing is then applied to the surface of the fibers by passing them over an applicator that continually rotates through the sizing bath to maintain a thin film through which the glass filaments pass.
- The components of the sizing impart strand integrity, lubricity, resin compatibility, and adhesion properties to the final product, thus tailoring the fiber properties to the specific end-use requirements.


Batch
Furnace
Forehearth
Bushing
Size
Forming
Winder

Important Commercial Products

- **Fiberglass roving** is produced by collecting a bundle of strands into a single large strand, which is wound into a stable, cylindrical package.
- This is called a multiend roving process.



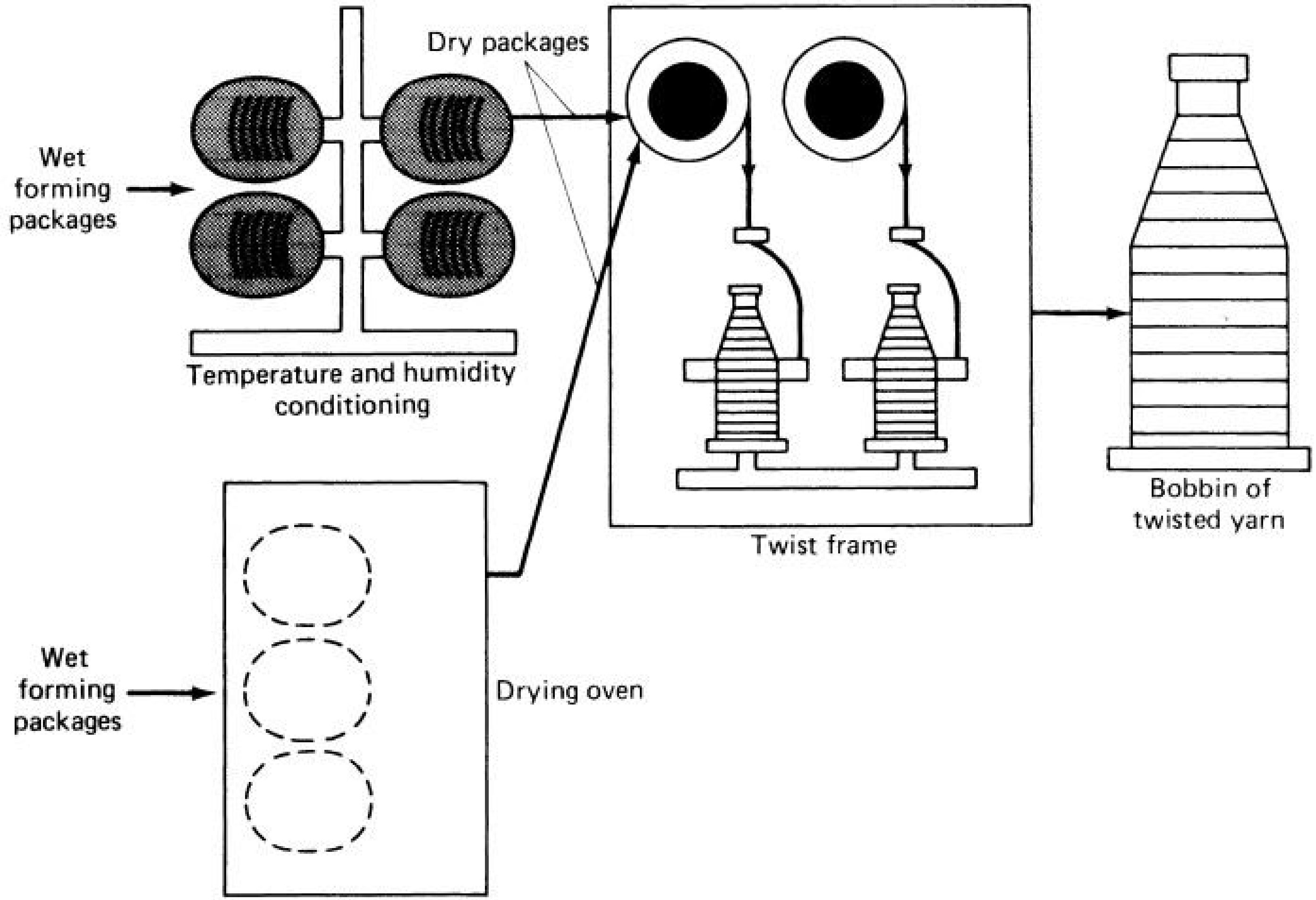
Multiend roving process production

Important Commercial Products

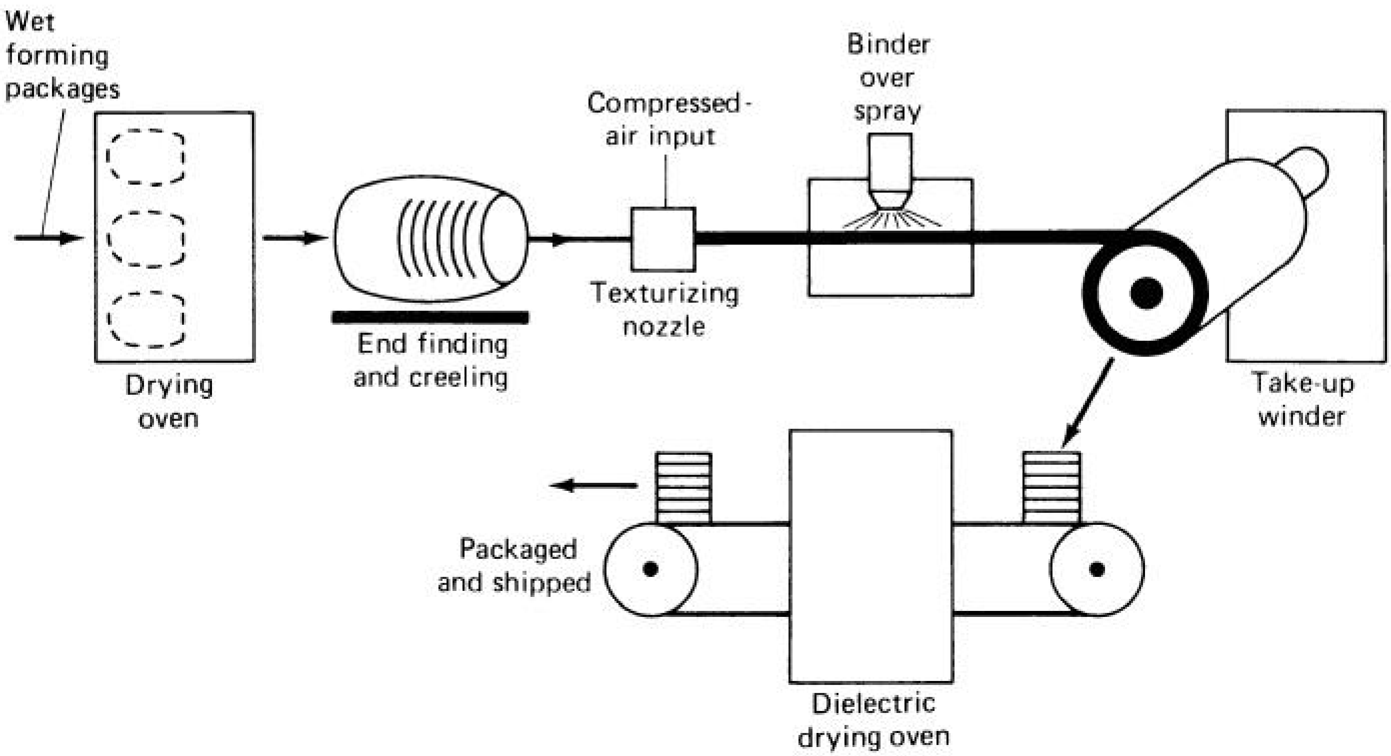
- **Woven roving** is produced by weaving fiberglass rovings into a fabric form.
- **Fiberglass mats** may be produced as either continuous- or chopped-strand mats.
- A chopped strand mat is formed by randomly depositing chopped fibers onto a belt or chain and binding them with a chemical binder, usually a resin.
- Continuous-strand mat is formed in a similar manner but without chopping, and, usually, less binder is required because of increased mechanical entanglement, which provides some inherent integrity.

Important Commercial Products

- **Fiberglass Fabric.** Fiberglass yarns are converted to fabric form by conventional weaving operations.
- **Textile yarns** are fine-fiber strands of yarn from the forming operation that are air dried on the forming tubes to provide sufficient integrity to undergo a twisting operation.
- **Texturized Yarn.** Texturizing is a process in which the textile yarn is subjected to an air jet that impinges on its surface to make the yarn ’fluffy’’



Twisting Operation



Texturizing

Important Commercial Products

- **Carded Glass Fibers.** Carding is a process that makes a staple fiberglass yarn from continuous yarn.

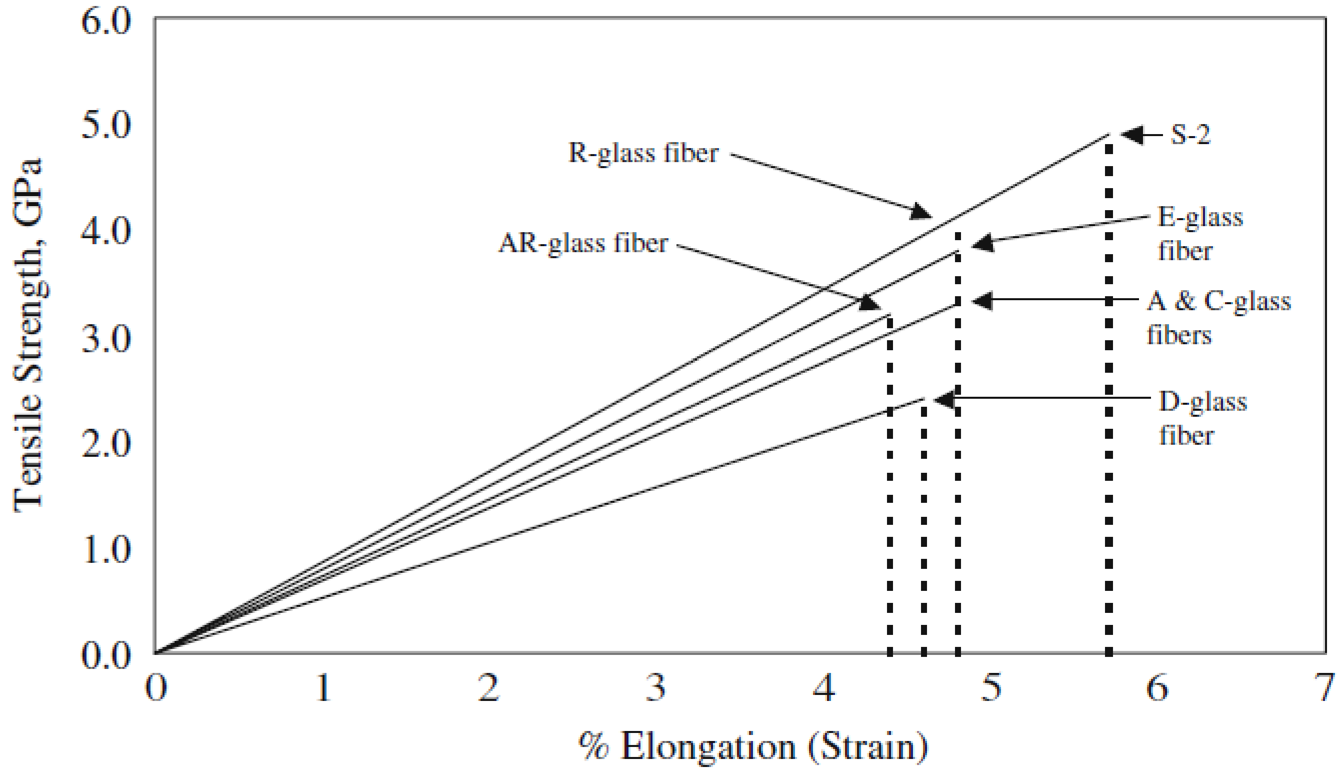
Properties

- Properties that have made glass fibers so popular in glass fibre reinforced composites include:
- Low cost
- High production rates
- High strength,
- High stiffness
- Relatively low density
- Non-flammable
- Resistant to heat
- Good chemical resistance
- Relatively insensitive to moisture
- Able to maintain strength properties over a wide range of conditions
- Good electrical insulation

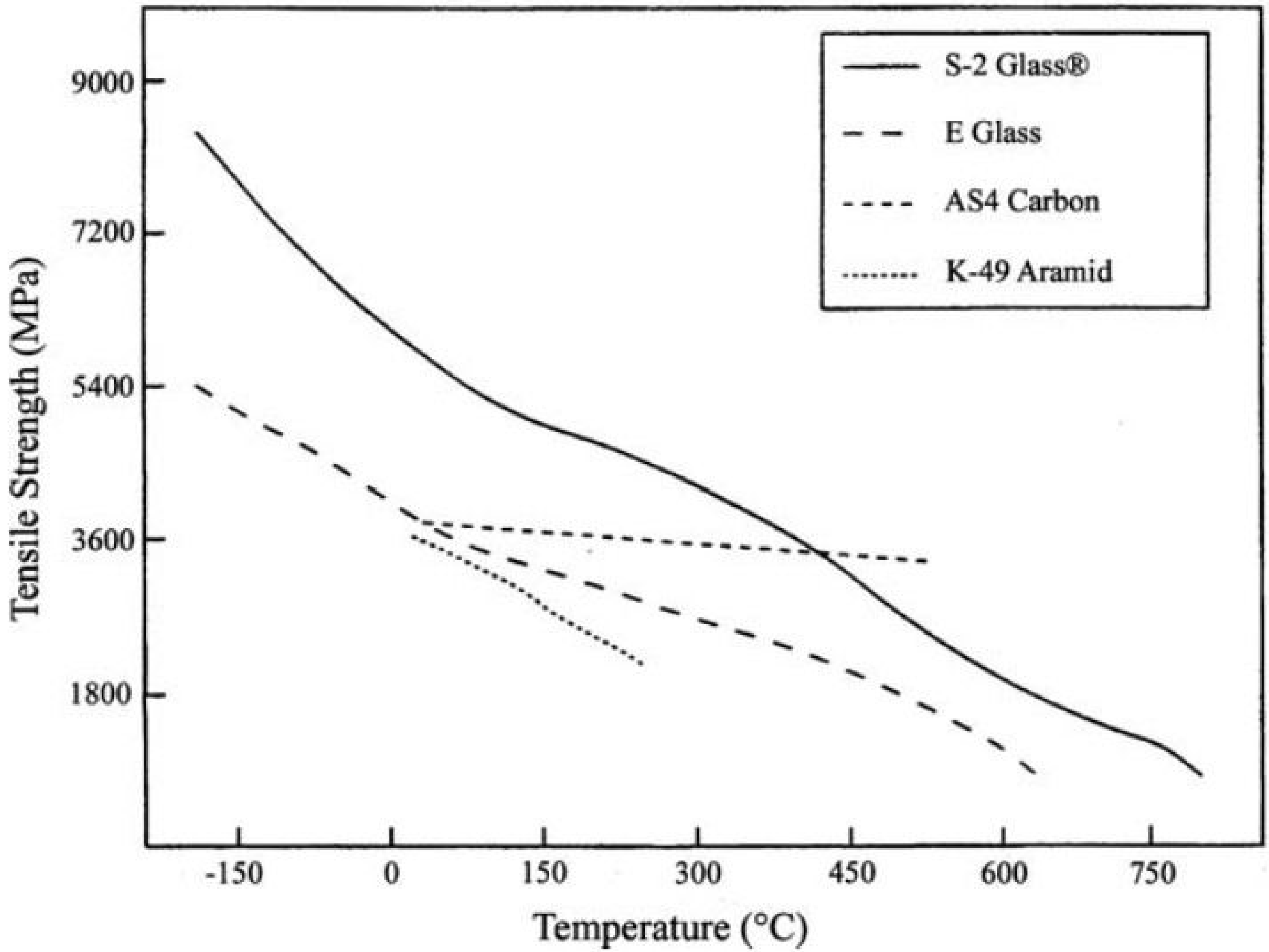
Properties of glass fibers

	A-glass	C-glass	D-glass	E-glass[a]	AR-glass	R-glass	S-2 Glass®
Density (g/cm^3)	2.44	2.52	2.11–2.14	2.58	2.7	2.54	2.46
Refractive index	1.538	1.533	1.465	1.558	1.562	1.546	1.521
Softening point (°C)	705	750	771	846	773	952	1056
(°F)	1300	1382	1420	1555	1424	1745	1932
Annealing point (°C)	–	588	521	657	–	–	816
(°F)	–	1090	970	1215	–	–	1500
Strain point (°C)	–	522	477	615	–	736	766
(°F)	–	1025	890	1140	–	1357	1410
Tensile strength							
–196°C, MPa	–	5380	–	5310	–	–	8275
ksi	–	780	–	770	–	–	1200
23°C, MPa	3310	3310	2415	3445	3241	4135	4890
ksi	480	480	350	500	470	600	709
371°C, MPa	–	–	–	2620	–	2930	4445
ksi	–	–	–	380	–	425	645
538°C, MPa	–	–	–	1725	–	2410	2415
ksi	–	–	–	250	–	310	350
Young's modulus							
23°C, GPa	68.9	68.9	51.7	72.3	73.1	85.5	86.9
Msi	10.0	10.0	7.5	10.5	10.6	12.4	12.6
538°C, GPa	–	–	–	81.3	–	–	88.9
Msi	–	–	–	11.8	–	–	12.9
Elongation percentage	4.8	4.8	4.6	4.8	4.4	4.8	5.7

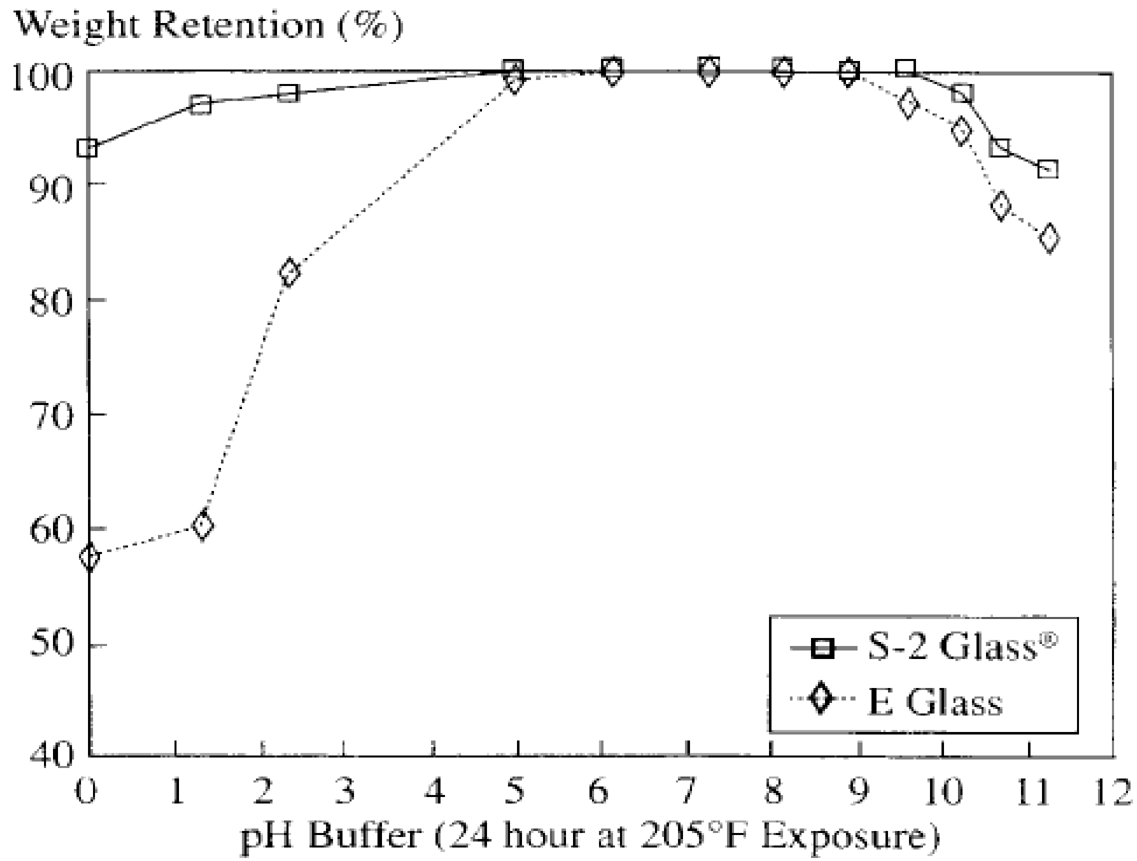
[a]Listed properties are for borosilicate E-glass compositions.



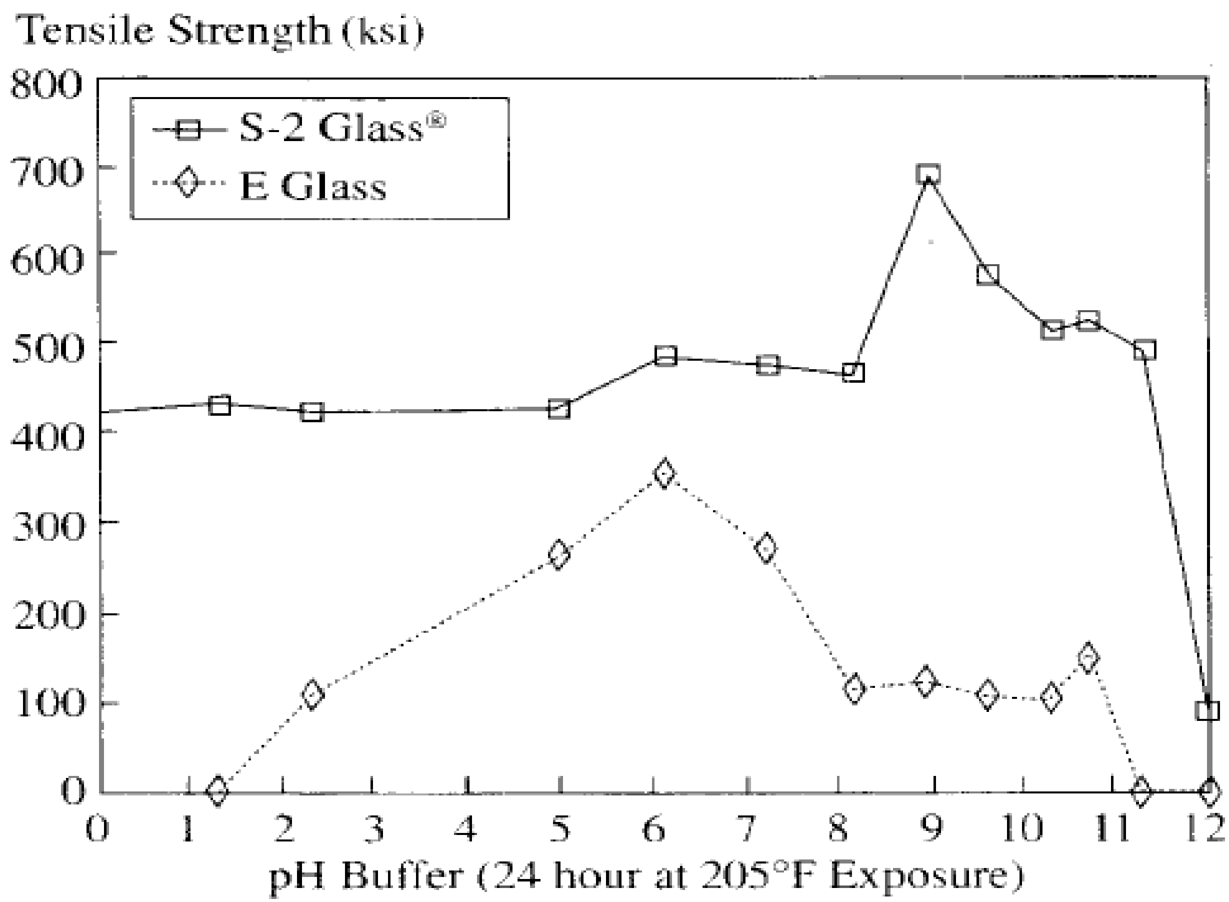
Single-fiber tensile strength at 23◦C for various glass fiber compositions



Fiber strength as a function of temperature



Fiber Weight Retention VS pH Exposure



Fiber Strength VS pH Exposure

Table 5.7 Comparison of properties for a variety of high-performance fibers

		Glass			Aramid	Carbon	UHMWPE	PBO
Category	Property	Units	E-glass	S-2 Glass®	K49	T700SC	Spectra® 1000	Zylon® HM
Physical	Density	g/cm^3	2.58	2.46	1.45	1.8	0.97	1.56
Mechanical	Tensile strength	MPa	3445	4890	3000	4900	2830	5800
Mechanical	Tensile modulus	GPa	72.3	86.9	112.4	230	103	280
Mechanical	Spec. tensile strength	km	136	203	211	278	298	379
Mechanical	Spec. tensile modulus	$x10^3$ km	2.9	3.6	7.9	13.0	10.8	18.3
Mechanical	Compress. strength	MPa	1080	1600	200	1570	170	561
Mechanical	Strain to failure	%	4.8	5.7	2.40	1.5	2.8	2.5
Thermal	CTE	10^{-7}/°C	54	29	–48.6	–38	1300	–60
Thermal	Softening point temperature	°C	846	1056	Oxidizes > 150	Oxidizes > 350	Melts at 147	Decomposes at 650
Price	Approximate price	$/kg	2	20	30–50	40–60	80	120
Reference					[41]	[49]	[44]	[48]

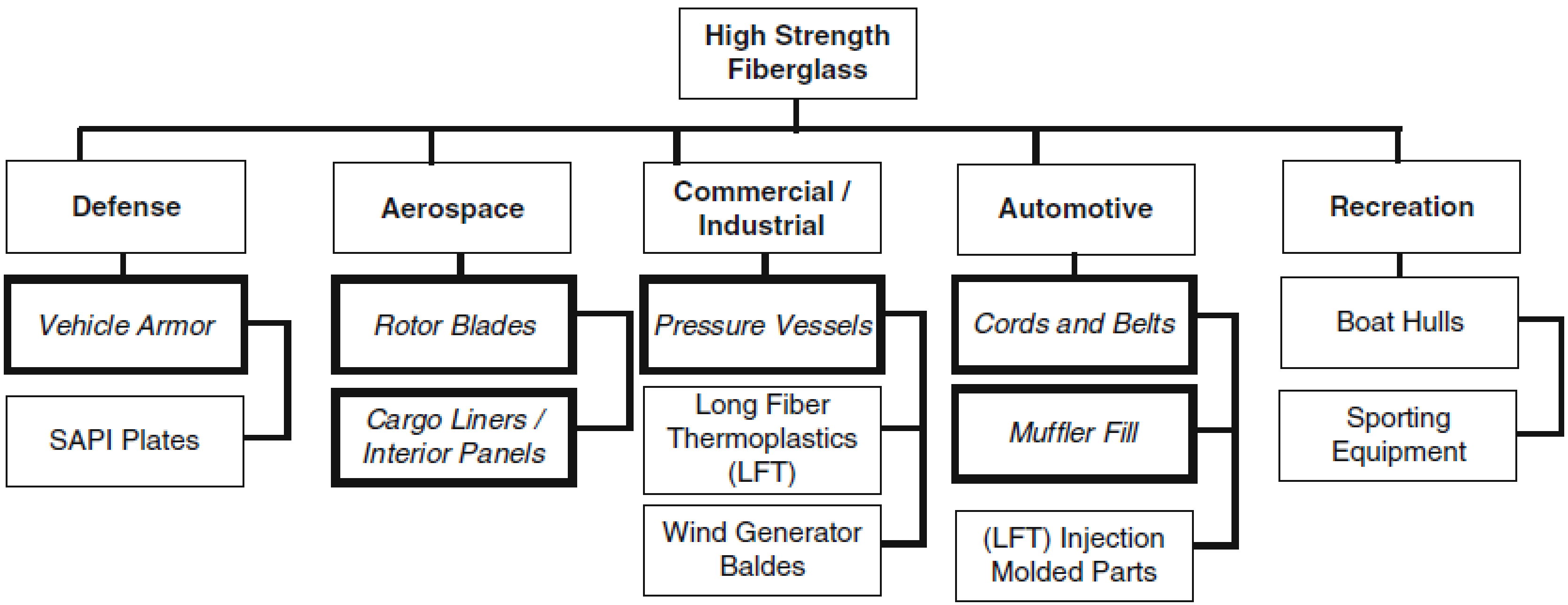
Data presented are typical values and thus will vary depending upon fiber denier
Dick Holland of Composite One, private communication

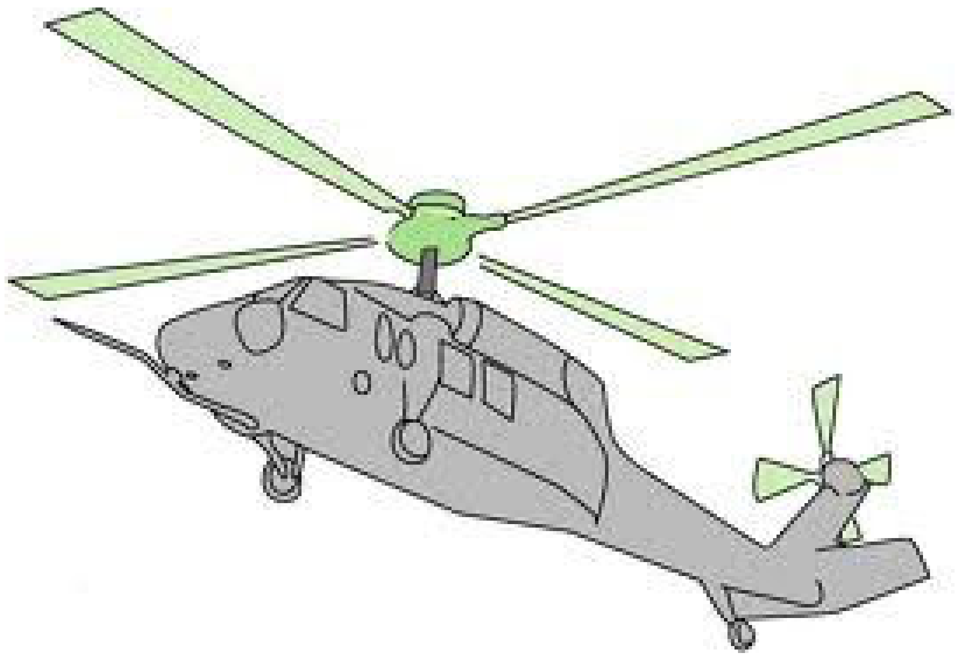
Inherent Advantages of Continuous Glass Fibers

- Fiberglass brings with it a unique set of advantages that set it apart from the rest of the field. These can be summarized as follows:

- *Thermal stability* – fiberglass is very stable and resists degradation at temperatures below its softening point for years. S-glass has a softening point of 1056°C and the highest use temperature.
- *Flammability or oxidation resistance* – since glass is inorganic, it does not burn making it a strong candidate where non-inflammability is a key requirement. Carbon and the polymer-based fibers, even Zylon, will eventually burn when exposed to flame.
- *Compressive strength* – both E- and S-glass exhibit excellent compressive strength. This is critically important for structural composites, which must bear load as part of their design criteria. This is one of glass' key advantages.
- *Cost* – compared to carbon and polymer fibers, fiberglass is relatively inexpensive. This is due to economy of scale in the case of E-glass where large furnaces can produce a few hundred tons per day. S-2 Glass, which is also made in a continuous but more specialized process, requires higher temperatures and thus costs more to operate. But it is still about half the price of aramid on a per kilogram basis.
- *Strength and modulus per unit price per kilogram* – on a cost per unit weight basis, HSG fibers represent the best value per dollar spent.

Applications



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Applications

- Transportation
- Electrical/Electronics
- Building Construction
- Infrastructure
- Aerospace/Defense
- Consumer/Recreation
- Medical Products

Construction & Demolition Waste Management

Waste

Waste, or rubbish, garbage, depending on the type of material or the regional terminology, is an unwanted or undesired material or substance. It is a unavoidable by-product of most of the human activity.

Classification of Waste

- Waste
  - Residential
  - Industrial
  - Commercial
  - Construction and Demolition
  - Institutional
  - Municipal Services
  - Agricultural

Construction and Demolition

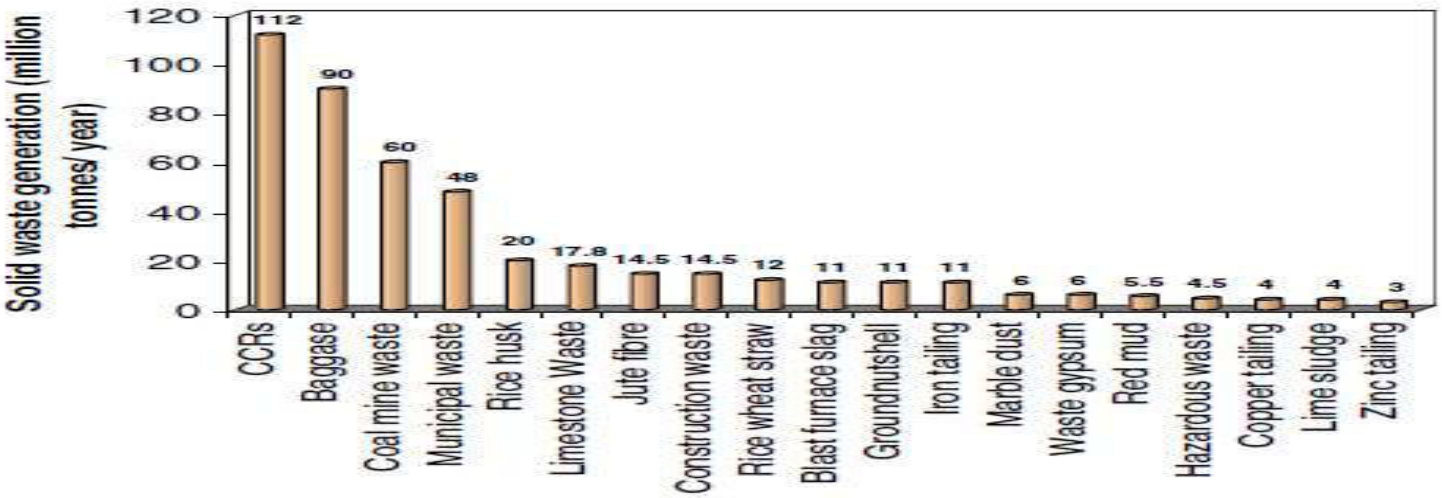
Waste building materials, dredging materials that are produced in the process of constructions, remodeling, repair, or demolition of residential buildings, commercial buildings and other structure and pavements.

Construction & Demolition Waste Consist of

- Concrete
- Bricks
- Timber
- Sanitary ware
- Glasses
- Steel
- Plastic

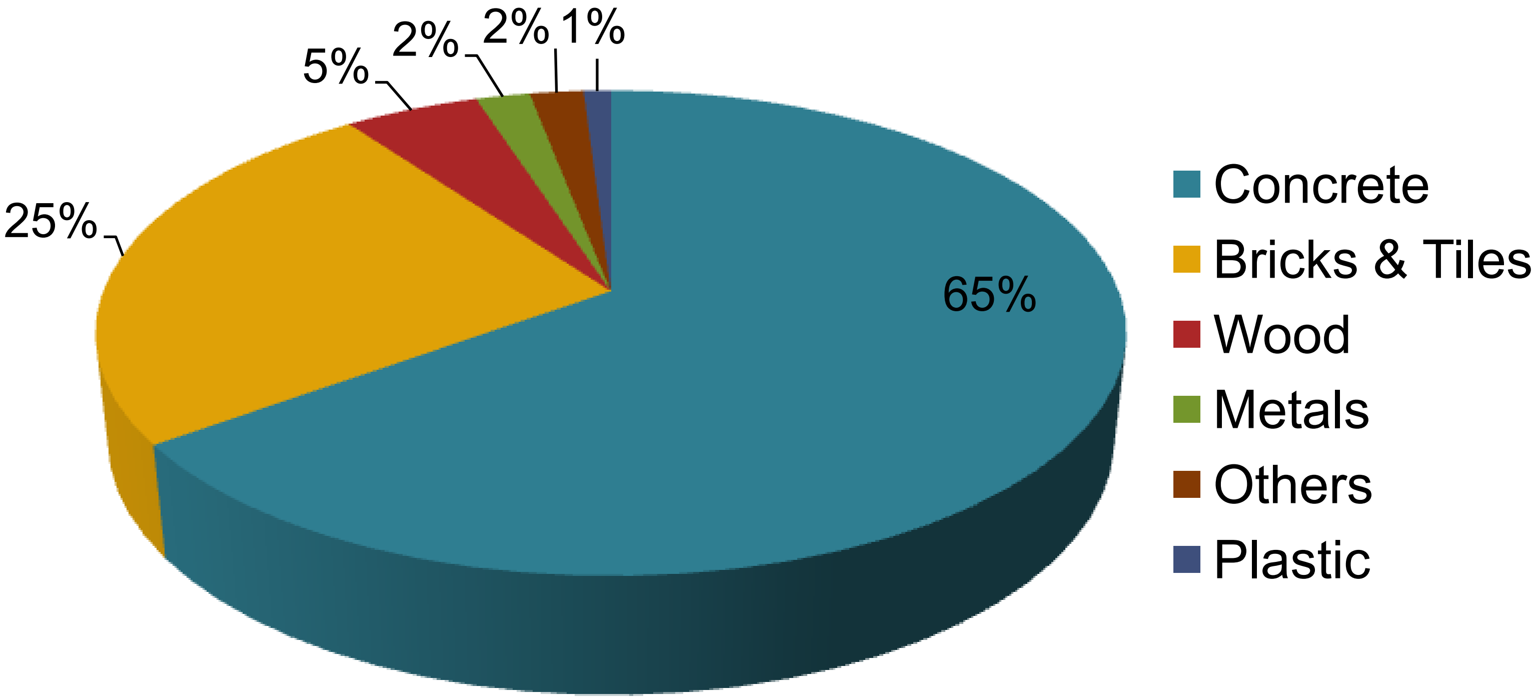
Present Indian Scenario of Construction and Demolition Waste

14.5 MT Out Of 48 MT of total solid waste generated per annum



Ref:-Dr., Asokan Pappu and Dr., Mohini Saxena and Dr., Shyam R. Asolekar (2007) *Solid wastes generation in India and their recycling potential in building materials.* Indian Journal Of Environmental Protection . pp. 2311-2321.

Composition of Construction & Demolition Waste in India



Ref:-Prof. S.K. Bhattacharyya, A.K. Minocha, Mridul Garg, Jaswinder Singh, Neeraj Jain, S. Maiti & S.K. Singh, GAP0072 (DST Project), Demolition Wastes as Raw Materials for Sustainable Construction Products, CSIR-CBRI News Letter, Vol-33 No-2 April-June 2013, pp. 1-2

Reasons For Increase of Construction & Demolition Waste

- Many old buildings, concrete pavements, bridges and other structures have overcome their age and limit of use due to structural deterioration beyond repairs and need to be demolished
- New construction for better economic growth
- Structures are turned into debris resulting from natural disasters like earthquake, cyclone and floods etc.

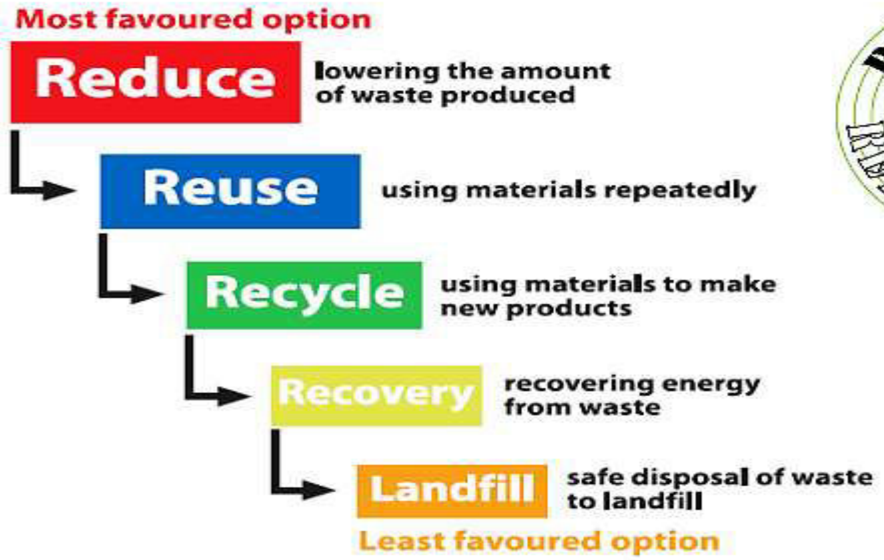
What to do?

- Store at source
  - appropriate storage space

- Segregate

- Then?

Hierarchy for C & D waste management



Reduction of Waste

- Ensuring materials are ordered on an "as needed" basis to prevent over supply to site;
- Minimize the creation of excessive scrap waste on site;
- Ensuring correct storage and handling of construction materials to minimize generation of damaged materials/waste;
- Ensuring correct sequencing of operations and assigning individual responsibility

Construction Waste Recycling

When considering a recyclable material, three major areas need to be taken in to account are:

- Economy
- Compatibility with other materials
- Material properties

Sorting Process of Construction & Demolition Waste

Chemical Mineralogical Appraisal

Mechanical Sorting

Chemical-Mineralogical Appraisal

- Recognizes particular grain size
  - X-Ray Fluorescence - Invest chemical composition in terms of major elements.
  - X-Ray Diffractometry - Recognizes the constitute mineralogical phases

Mechanical Sorting Process

- Bar Screening
- Magnetic Separation
- Air Classifier

Recycling and Reuse

- Reuse (at site) of bricks, stone slabs, timber, conduits, piping railings etc. to the extent possible and depending upon their condition;
- Plastics, broken glass, scrap metal etc. can be used by recycling industries;
- Rubble, brick bats, broken plaster/concrete pieces etc. can be used for building activity, such as, leveling, under coat of lanes where the traffic does not constitute of heavy moving loads;

Contd..

- Larger unusable pieces can be sent for filling up low-lying areas;
- Fine material, such as, sand, dust etc. can be used as cover material over sanitary landfill.
- Excavated soil can also be used creatively in the landscaping of developments and for the construction of embankments and screening/noise abatement berms in civil engineering projects.

Recovery and Landfill

- Conversion of non-recyclable waste material into usable heat in form of fuel or electricity.
- Industrial Waste Stabilizer- Material having no value in reuse, although employed for beneficial use in stabilization
- Reuse public fill at public filling areas for reclamation.
- Landfill is the least preferred option although if required it should done after considering all the laws and regulation.

Main Issue for Construction & Demolition Waste Management

- Absence of segregation of waste at source
- Lack of appropriately located recycling facilities
- Indifferent attitude of citizens toward waste management due to lack of awareness.
- Illegal landfill practices done by contractor for saving money.

Key Requirement of Waste Management Plan

- Types, quantities and qualities of wastes
- Measures for reducing waste generation
- On-site waste sorting
- On-site and off-site reuse
- Areas for waste storage
- Quantities of wastes requiring off-site disposal
- Monitoring and auditing program

Case Study 1: State Offices at Butterfield Way, Sacramento, CA

- The site work construction phase for the California Franchise Tax Board's State Offices at Butterfield Way realized tremendous financial benefits from recycling C&D debris. This led the project team to an extremely high 99.6% (by weight) C&D waste diversion rate for this phase. Sixty-nine percent of this waste (over 15,000 tons) was recycled, stored and reutilized on-site.

Conclusion

- It has been established that materials & components from demolished buildings are being reused for new construction works as well as renovation projects, especially by low- income communities in developing countries.

- In developing countries most of the demolition rubble is dumped, the developed world has now started to recycle it into aggregate for non-structural concrete.

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- It is hoped that recycling waste materials for use in the building will cut down costs of producing new raw materials thereby reducing consumption of natural resources like energy & reduces usage of landfills.
- As sorting and recycling facilities become more wide spread and better developed it will be easier to redirect our waste from landfill.

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The Choice Is Yours

To Landfill

To Recycle

THANK YOU