

Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 01

Phosphogypsum

Hello students. So, today we will look at another building material which we term as an alternative building material and that is phosphogypsum. Today's class will be relatively shorter I suppose because phosphogypsum is an upcoming building material. In the sense of how it is seen as a sustainable building material. And more needs to be done in this domain and therefore, I wanted to include this in this course. We will look at today the production of phosphogypsum.

What are its characteristics? How is it beneficial to us? What are its limitations, its applications and how it is used in buildings. So, phosphogypsum is a byproduct which is created during the wet manufacturing of phosphoric acid. Often treated as industrial waste, Phosphogypsum is a byproduct of the phosphoric acid production process, which is rich in calcium sulfate. With proper treatment, it can be used as a sustainable alternative building material.

Each year, 200 to 300 million tons of phosphogypsum is produced globally. But a staggering 85% is improperly dumped. This causes huge environmental issues. Only around 15% is used in fertilizers and construction put together. Different countries manage phosphogypsum differently.

Japan uses it in gypsum construction, while the United States and Britain stockpile it. However, long-term storage causes environmental risks including soil and water pollution as well as the potential release of hazardous pollutants into the air, raising concerns about its disposal worldwide. Phosphogypsum is a special kind of gypsum created when making phosphoric acid. Every ton of acid production results in 5 tons of phosphogypsum. This process causes environmental issues.

However, research shows that both sedimentary and igneous phosphogypsum can be used in building materials. Using up to 50% phosphogypsum in construction meets safety limits for radioactivity. When turned into bricks or plates, phosphogypsum doesn't release harmful substances much. Heating phosphogypsum helps get rid of humid impurities and makes it stronger. Cement made with phosphogypsum is super strong.

suggesting it could be a great sustainable building material. Phosphogypsum, a synthetic gypsum resulting from phosphoric acid production, poses environmental challenges because a lot of it gets

dumped. Calcination produces impurities and increases its mechanical strength. Phosphogypsum based cementitious systems achieve high compressive strengths offering potential sustainable solutions in construction. So phosphogypsum can be used in the cement industry, it can be used with Portland cement, super sulfated cement, calcium aluminate cement and sulfur aluminate cement.

It can be used in cement based materials like concrete, mortars, grouts. It can be used in road based pavements for soil stabilization and adobe wall stabilization. It can also be used in the manufacture of tiles ceramic, wall board and brick block. Let us look at the characteristics of phosphogypsum in concrete. Using phosphogypsum in concrete has interesting effects on strength.

As the concrete ages, its strength increases specially after 28 days with different water binder ratios. However, if we replace too much cement with phosphogypsum, the strength drops a lot causing issues. The flexibility of the concrete known as flexural strength also decreases when we use more phosphogypsum or increase the water binder ratio leading to more cracks. For certain types of concretes like standa, when using phosphogypsum in concrete, this strength increases somewhere around 28 days. but it should have a different water binder ratio.

Now, flexural strength decreases significantly when higher phosphogypsum replacement and increased water binder ratio is done causing more crack grades like M25, M30, M35, M40 and so on. You can use 10 to 30 percent phosphogypsum with water binder ratio of 0.4 to 0.65. For ordinate concrete grades like M10, M15, M20, 10 to 30 percent phosphogypsum with water binder ratio of 0.

55 to 0.65 is appropriate. Let's look at the benefits of phosphogypsum. There is a reduction in density by introducing phosphogypsum which results in a decreased matrix density contributing to lightweight and potentially more efficient construction materials. The inclusion of phosphogypsum improves the chemical resistance of the matrix, enhancing its durability against corrosive elements and chemical exposure. Phosphogypsum incorporation enhances the matrix ability to withstand the challenges of freezing and thawing cycles, making it more suitable for regions with variable climate conditions and high diurnal variations.

It has increased fire resistance, particularly notable at 10% for phosphogypsum content. This matrix exhibits heightened fire resistance offering improved protection against high temperature conditions in various applications. Hence, adding phosphogypsum to construction materials have shown several benefits. It makes the material lighter by reducing its density which can lead to more efficient construction. It can also enhance the material's ability to resist chemicals making it more durable against corrosive elements.

It improves the material's resistance to freezing and thawing making it suitable for regions with very high diurnal variations. Finally, 10% phosphogypsum content in a material makes it more resistant to fire providing better protection in high temperature conditions. Overall, using phosphogypsum can create construction materials that are lighter, more durable, weather resistant

and better at withstanding fires. The other advantages of using phosphogypsum are it is an environmentally friendly material. Utilization of phosphogypsum reduces the environmental impact by repurposing a waste product into beneficial construction materials.

It is fire resistant. Building products made with phosphogypsum offer excellent fire resistance, enhancing the safety of structures and the occupants. It is a cost effective building material. So, phosphogypsum based materials provide a cost effective solution for construction projects without compromising on quality. Of course, it comes with its own limitation.

Let us look at the limitations. First is decreased workability. The introduction of phosphogypsum in the matrix leads to reduced workability posing a challenge in handling and shaping during construction. There is a reduction in its mechanical strength. So incorporating phosphogypsum results in a decline in the mechanical strength of the matrix impacting its overall structural integrity.

It has diminished abrasion resistance. So the matrix experiences a decrease in abrasion resistance, potentially affecting its ability to withstand wear and tear in practical applications. It has elevated drying shrinkage. So introducing phosphogypsum leads to an increase in drying shrinkage, which may pose issues such as cracking and dimensional changes in the matrix. It has increased soundness expansion.

So, the inclusion of phosphogypsum causes an expansion in soundness, potentially compromising the stability and performance of the matrix. It has higher thermal conductivity. So the matrix exhibits higher thermal conductivity when phosphogypsum is introduced influencing its insulation properties and thermal performance. One another limitation is it can have radioactive elements. So phosphogypsum may contain low levels of radioactive elements which require proper handling and disposal.

In a nutshell, using phosphogypsum in construction material has its own challenges. Firstly, it makes the material less easy to work with making it harder to shape during construction. Secondly, it reduces the strength of the material affecting its overall structure. Thirdly, the material becomes more prone to wear and tear due to decreased abrasion resistance. Additionally, introducing phosphogypsum can lead to increased drying shrinkage causing potential issues like cracking.

Furthermore, the stability and performance of the material may be compromised as it experiences soundness expansion. Lastly, the materials insulation properties are affected as phosphogypsum increases its thermal conductivity. These limitations highlight considerations when using phosphogypsum in construction. Let us now look at the applications of phosphogypsum. Now phosphogypsum is extensively employed in cement, wallboard, ferrocement, plaster, tiles and various building materials.

We can have infrastructure base When phosphogypsum is mixed with fly ash or cement and serves as a base for roads, storage areas and parking lots. It has specialized application when it is

used in sulfur polymer concrete, polymer flooring and polymer composites. It has geopolymer enhancement as it enhances compressive strength in fly ash based geopolymers offering improved fire resistance after elevated temperature exposure. The phosphogypsum also has insulating properties making it suitable for manufacturing thermal insulation materials essential for energy efficient buildings. In a crux, phosphogypsum finds diverse applications in construction.

It's commonly used in making cement, wallboard, ferrocement, plaster, tiles and various building materials, showcasing how it can be a very versatile material. Phosphogypsum can be mixed with fly ash or cement to form a strong base for roads, storage areas and parking lots. It also employed in specialized applications like sulfur polymer concrete, polymer flooring and polymer composites. Additionally, when added to fly ash based geopolymers, phosphogypsum can enhance compressive strength and improves fire resistance after exposure to high temperatures. These applications demonstrate the usefulness of phosphogypsum in creating robust and versatile construction materials.

Let us now look at the application of phosphogypsum in buildings. Phosphogypsum is crucial in making cement, wallboard, ferrocement, plaster and tiles. So, phosphogypsum can be used in any of these. As an infrastructure base, it forms a strong base for roads, storage areas and parking lots when mixed with fly ash or cement.

It has specialized uses. It is used in applications like sulphur polymer concrete, polymer flooring and composites. It has geopolymer strength and in fly ash based geopolymers it enhances compressive strength improving durability and fire resistance. Hence phosphogypsum can offer diverse contributions. The phosphogypsum's diverse application makes it a key ingredient in constructing resilient and innovative buildings. Phosphogypsum plays a vital role in constructing buildings.

It is widely used in making cement, wallboard, ferrocement, plaster and tiles. contributing to the construction industry's diverse materials. When combined with fly ash or cement, phosphogypsum forms a sturdy base for infrastructure like roads and parking lots. In specialized applications, it is employed in creating sulfur polymer concrete, polymer flooring and polymer composites showcasing its versatility. Moreover, When added to fly ash based geopolymers, phosphogypsum enhances the compressive strength, ensuring durability.

The various applications highlight how phosphogypsum is an essential ingredient in constructing strong, versatile and innovative buildings. Left to itself, phosphogypsum does not have much of use and ends up in landfill. It is such a waste of a material which when combined with other materials to form a composite matrix has its own inherent applications and strengths. If we are able to maneuver its limitations, phosphogypsum can be a wonder material which will help in less dumping of waste and in trying to utilize a waste product into building material giving rise to an alternate building material. So, let us try to experiment more and use phosphogypsum in buildings.

I will stop this class here. and we will continue our next class with yet another building material.