EXPERIMENTAL STUDIES ON THE USE OF PYKRETE (FROST MATERIAL) AS A CONSTRUCTION MATERIAL

Abstract

It involves using ice as a building material but also comes with certain restrictions. In comparison to traditional building materials, ice exhibits an excessive creep behaviour and is a comparatively weak substance. Even in the coldest region, prompt protection is required due to the considerable temperature dependence of the mechanical characteristics of ice. It has been discovered that by creating artificial ice composites, the qualities of ice and sea ice may be reinforced. The categorization of the different ice reinforcing techniques is shown. Despite several articles on the subject, applications for ice composites are somewhat restricted. The report gives a summary of all current ice structure-related building techniques.Only two forms of ice composites, including pykrete and ice reinforcement, have now been used effectively in the engineering of structures for a variety of tasks. There is a brief overview of these initiatives. The projects' or the "Pykrete Dome's" description is expanded. Finland is home to the biggest pykrete dome ever built. Pykrete suggested it as a potential material for a massive aircraft carrier during the first world war. Due to its limited thermal conductivity, Pykrete has peculiar characteristics such as a comparatively slow melting rate and much higher strength and toughness compared to ice. If the substance is kept frozen, these physical characteristics may allow it to be compared to concrete. Pykrete swells during the freezing process, making it a little difficult to create than concrete. Sea water may be used as a raw resource for maintenance and repair, though. If stored at or below freezing temperature, the mixture may be moulded into any shape and frozen; it will remain strong and resilient. It is possible to increase resistance to progressive creep or drooping by reducing the temperature.

Keywords : Ice as construction material, Pykrete, Bunkers for military use, Bullet proof material, Increase melting point, toughness, tensile strength.

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I. INTRODUCTION

A frozen composite material called Pykrete was initially created using ice and sawdust or another type of wood pulp, such paper. In cold climates, a variety of building projects can employ this frozen material, also known as Pykrete as ice blocks. Switzerland, the Antarctic, Kashmir, etc. In World War 2, Geoffrey Pyke was successful in convinced others that the material for the supersized aircraft carrier he had created is a possibility. Pykrete has unique qualities for the British navy. It is well known that using ice as a construction material has several restrictions. Vaseline and Pronk studied this in their 2015 study. Since it has a high degree of creep tendency, ice is a fairly weak substance compared to recommended construction materials.

Every winter, in frigid regions all around the world, bridges and ice highways are built across rivers, lakes, and seas. This construction frequently entails removing snow from the existing ice cover to let the ice sheet to thicken naturally or flooding the ice with consecutive thin layers of water that cause it to freeze and thicken from the surface. In either scenario, the ice sheet's bearing capability is increased by its thickness. Heinz Isler (1926-2009) designed and created ice shell constructions using fabric formwork, according to Arntz and Hermens' [2016] presentation. Isler was regarded as a creative and unconventional thinker. In order to find stable shapes for shell constructions and funiculars, he exploited gravity. Around 1957, he began to explore with actual models. He used frozen stretched sheets hung in the air as one of his working techniques. Every winter, he conducted several experiments with frozen cloth or by misting plants, hanging ropes, and delicate garden nets with water. Heinz Isler conducted tests with balloons sprayed with water when it was cold in addition to his wintertime studies with hanging materials. As a result, there was an ice palace.1946 M. F. Perutz Therefore, it was only inevitable that a plan for the ostensibly inexpensive building of enormous aircraft carriers that could fly land-based aircraft thousands of miles from their base would be given significant consideration. The plan's creator, Mr. Geoffrey Pyke, suggested that an iceberg, either manmade or natural, be hollowed out to create space for planes and levelled to serve as a sufficient runway in a report he sent to the Chief of Combined Operations in October 1942. If not permanently, but at least until it served its strategic function, it needed to be mobile and insured against melting. Mr Pyke highlighted that all strategic resources, such as metals, wood, and concrete, were already fully utilised for the war effort and that ice, which only required 1% of the energy required to produce an equivalent weight of steel, would be the ideal building block for large carriers.

Figure 1: Wood Dust

II. MATERIALS

The most important parameters have been discussed in this research paper:

1. Materials Used

- **ICE:** Water freezes into ice, which is a solid. depending on the presence of contaminants like soil or air bubbles, may seem clear or more or less opaque and bluish-white in colour. The packing geometries (phases) of ice molecules can vary by seventeen or more depending on temperature and pressure. Typically, people imagine that ice is brittle at low temperatures and deformable at high temperatures. Ice operates in a more complex manner than this. Ice has been described as being brittle-plastic. When tension is applied to ice, brittle fracture occurs, even when the temperature is close to the melting point. It results from the hexagonal crystal structure's stacked layers. These layers distort at high temperatures when they dislocate and slide over one another like a deck of cards. When a force is applied quickly, brittle fracture happens because the movable dislocations are unable to move quickly enough to keep up with the stress. At lower temperatures, the rate of deformation is reduced, but it still happens when a load is applied over time to a fixed point.

- **Wooddust:** Pykrete, often referred to as picolite, is a composite material that is formed of around 14% sawdust (paper flakes or wood pulp) and 86% water by weight before being frozen. Max Perutz creates it during World War II. Geoffrey Pyke submitted the material to the Royal Navy of the United Kingdom under the moniker Project Habakkuk. The material was a contender for building a large, unsinkable aircraft carrier. Aluminium and steel were in scarce supply and needed for other things. Interesting characteristics of Pykrete include its poor heat conductivity, which causes it to melt rather slowly, and its superior strength and toughness to pure ice—it is really closer to concrete—while maintaining its ability to float on water. Water and any porous and fibrous material, such as wood dust or torn paper, may be used to create Pykrete simply. Anything that can be formed with this wet pulp can be frozen to form a solid that is strong and unbreakable. Particleboard's major ingredient is sawdust. Particulate matter and particles are what make up wood dust. The study of wood dust control is within the domain of indoor air quality engineering, but research on the health risks associated with wood dust falls under the domain of occupational health science.

- **Paper:** When wet cellulose pulp fibres from wood, rags, or grasses are compressed together and dried into flexible sheets, paper is produced. It is an adaptable substance with a wide range of applications, including writing, printing, packing, cleaning, and other industrial and construction activities. The Han court eunuch CaiLun is credited with developing the pulp papermaking technique in China around the early 2nd century CE, maybe as early as the year 105 CE, while the first paper-related archaeological artefacts date from China's 2nd century BCE. China leads worldwide output in the contemporary pulp and paper sector, with the United States following behind.

- **Cocunut Husk:** Ash from coconut husks is an industrial waste that is utilised as fuel waste all over the world. The combustion produces ashes that are mostly made up of silicon and aluminium oxides, as well as significant amounts of unburned material.

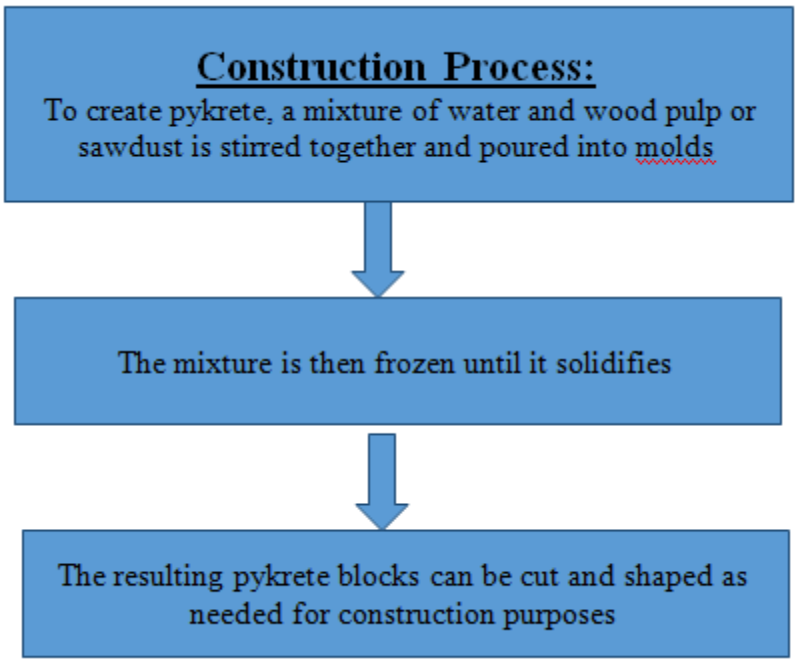
2. Various Notations Used

- Water (W)
- Wood Dust (WD)
- Paper (P)
- Coconut Husk (CH)

3. Objective

- To elevate crushing strength.
- Compressive strength need to improve.
- To evaluate the differences between Paper Pykrete Blocks and Regular Ice blocks with Pycrete Wooddust Blocks.

4. Methodologies



5. Scope For Future Work

- Suitable for making Igloos and Domes
- It can used as Bullet proof material
- Can be used to build bunker like structures for the Military

6. Test to Be Conducted

- **Impact Value Test:** When comparing the impact values of various materials, it can be shown that super Pykrete has a higher impact value than pykrete and that pykrete has a higher impact value than a typical ice block.

Table 1: Impact Value Test

MATERIAL	NO. OF BLOWS
W	1
W + WD	15
W + P	23
W + CH	35

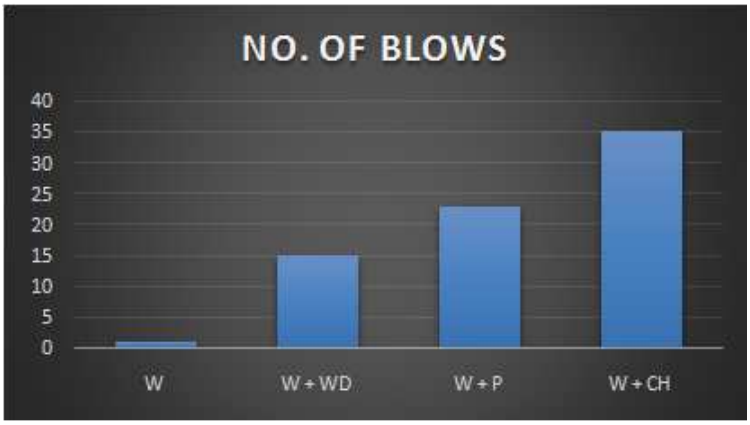


Figure 2: Impact Value Test

- **Compressive Test:** A compression tester, a specialised device used in testing laboratories, is often used to provide controlled compression to test samples. This test is among the most important since the compressive strength of the material is an essential metric.

Table 2: Compressive Test

SL.NO	MATERIAL	MAX. LOAD AT FAILURE	DISPLACEMENT
1	W	19	23.50
2	W + WD	112	62.50
3	W + P	105	68.00
4	W + CH	117	54.00

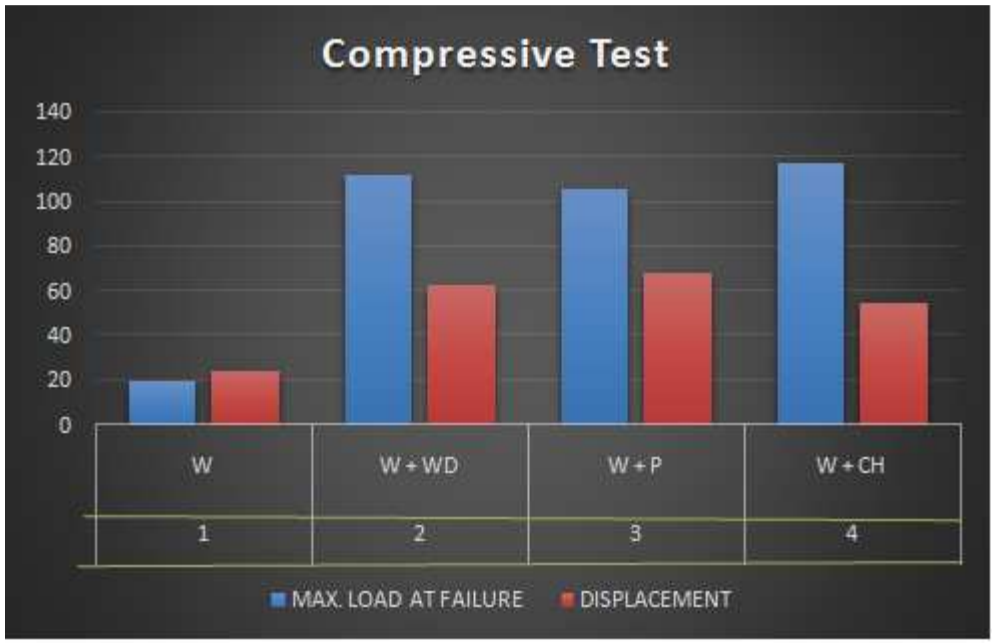


Figure 3: Compressive Test

III. CONCLUSION

It is clear from the current experimental investigation and literature analysis that adding paper and wooddust to the ice-making process improves the ice's characteristics over plain ice. Pykrete and Super Pykrete now have a strength both impact and compressive strength that is around three times higher than that of a typical ice block. When compared to other combinations of wood dust and paper, the results demonstrate that water and coconut husk have a good impact value and compression.

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