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EXPERIMENTAL STUDY ON THE EFFECT OF FLY ASH AND STEEL FIBERS AND REPLACEMENT OF FINE AGGREGATE BY QUARTZITE POWDER IN ULTRA-HIGH-STRENGTH CONCRETE

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ABSTRACT

The term reactive powder concrete (RPC) has been used to described a fiber reinforced, super plasticizer, silica fume-cement mixture with very low water -cement ratio, characterized by the presence of very fine aggregates instead of ordinary aggregate. Fibers are incorporate in RPC in order to enhance the fracture properties of the composite materials. Reactive powder concrete is not yet available with the limited research in this area. Reactive powder concrete is an ultra-high-performance concrete (UHPC) developed years ago by Bouygues with the aim to build strong, durable and sustainable structure. Some differences can be underline between the RPC and high-performance concrete (HPC); that is to say RPC exhibits higher toughness, lower porosity and lower permeability compared to HPC. Microstructural observation confirm that silica fume enhances the fiber -matrix interfacial characteristics, particularly in fiber pullout energy.

Reactive powder concrete (RPC) is an ultra -high strength composite material, it's made of mixture of cement, quartzite powder, Nano silica, silica fume, fly ash, GGBS, super plasticizer, and steel fiber. The terms of "reactive powder" means that all the powder components in the RPC are chemically reactive, has been used to illustrate Fibers reinforced, super plasticized, silica fume -cement mixture with very low water cement ratio. It is having compressive strength 142Mpa.

Keywords: OPC, Silica Fume, Quartzite Powder, Compressive Strength, Workability, Steel Fiber, Super Plasticizer, Nano Particle, Compressive Strength.

I. INTRODUCTION

Reactive powder concrete is most popular engineering material is a concrete. Its s used for building, Industrial structure, Bridges and Dams. Every day the concrete is improving. We all know the reactive powder concrete means without coarse aggregate or coarse aggregate free concrete that is the fine aggregate (contains cement, sand, silica fume, sand, quartz powder, super plasticizer, nano polymer and steel fiber with very low binder ratio) replacement of coarse aggregate and achieve better characteristics, lesser price and to be environmental acceptable.

Reactive powder concrete is ultra -high strength and high ductile composite material with advanced mechanical properties developed in France by researchers P. Richard and M. Cheyrezy was first produced in the early 1990s by researchers at Bouygues laboratory in France. The world's first Reactive powder concrete structure as, the Sherbrooke Bridge in Canada, was erected in July 1997.The addition of supplementary materials, elimination of coarse aggregate, very low water/binder ratio, additional fine steel fibers heat curing and application of pressure before and during setting were the basic concepts on which it was developed.

RPC structural elements can resist chemical attack, impact loading from vehicles and vessels and sudden kinetic loading due to earthquake. Ultra-high performance is the most important characteristics of RPC.RPC is composed of more compact and arrange hydrates. The micro structure is optimized by precise gradation of all particles in the mix to yield maximum density. It uses extensively the pozzolanic properties of highly refined silica fume and optimization of the Portland cement chemistry to produce highest strength hydrates.

The Reactive powder concrete (RPC) include higher durability, ductility and strength in comparison with normal concrete and fiber reinforced concrete due to its extremely low porosity, high tensile /compressive strength and ductile tensile behavior. In comparison with normal steel reinforced concrete, the application of RPC is expected to improve the resistance of buildings in infrastructure under extreme mechanical and environmental loads.

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Currently to achieve excellent mechanical behavior some special techniques and raw materials must be adopted in the preparation of RPC, which include:

A) Coarse aggregate is removed to enhance the homogeneity of concrete.
B) Metal fiber or steel tube is introduced to improve ductility composites.
C) High quality super plasticizer and large quantities of superfine silica fume and quartz are added, to achieve a low water/binder ratio to reduce porosity and improve strength.
D) Pressure may be applied before and during the setting to increase the compactness of the concrete.
E) High activity micro -Silica or precipitated silica may be mixed into cementitious materials to accelerate the hydration of cement and catalyze a strong pozzolanic reaction effect.
F) Steam curing may be supplied to gain higher strength.

In short, to gain the desire strength of UHPC, well-chosen raw material and sophisticated technical procedures are conventionally required. The RPC offers superior technical characteristics including ductility, strength and durability while providing highly moldable products with high quality surface aspect.

OBJECTIVE OF STUDY

To solve the problem of sudden failure (no ductility), this study aims at investigate the strength properties of Reactive powder concrete (RPC) compared to conventional concrete. The main objective of this study are: -

- Developed a mix design and produce RPC based on selection of composition materials, proper mix proportions and curing conditions to achieve the compressive and tensile strength and it is depending upon the packing density method.
- To deduce on suitability of RPC in the construction of high strength structures based on the compressive strength and tensile strength
- Addition small- sized steel fibers to improve ductility.
- Elimination of coarse aggregate for enhancement of homogeneity.
- Addition quartzite powder replace of coarse aggregate.
- Optimization of the granular mixture for the enhancement of compacted density.
- Post -set-heat treatment for the enhancement of microstructure.
- The optimal usage of super plasticizer to reduce water cement ratio.
- Addition Nano Silica particle for improving permeability and strength of concrete and also rapid early strength – gain. The advantage of Nano Silica is the higher surface area.

II. LITERATURE SURVEY

1. Cheyrezy and Richard (1995) developed an ultrahigh strength ductile concrete with the basic principles of enhancing the homogeneity by elimination the coarse aggregate, enhancing the microstructure by post -set heat treatment and the tensile strength of concrete was increased by incorporation small, straight, high tensile micro-fiber. Two type of concrete were developed and designated as RPC 200 and RPC800, which had exceptional mechanical properties.
2. Chan and chu (2002) has studied the effect of silica fume on the bond characteristics of steel fiber matrix of reactive powder concrete by bond strength, pullout energy, etc. Various silica fume contents ranging from 0% to 40% are used in the mix proportions. Results of them show that the incorporation of silica fume can effectively enhance the fiber-matrix interfacial properties, especially in the fiber pullout energy
3. Liu (2009) works and recommended natural fine aggregates and admixture to replace quartz powder and silica fume in RPC respectively. Under the condition of hot water or autoclaved curing with compressive strength > 200 Mpa, flexural strength >50 Mpa and pull-compression ratio >.27 was successfully prepared. The cement, silica fume, fly ash and composite system were used to give full play to superposition and composition complementary effect among all kinds of materials.
4. Zhu et al (2016) studied the mechanical properties and durability of RPC contained rice husk ash, and compared the effects of quartz sand and natural sand on the properties of RPC.Test result showed that flexural strength and fluidity of RPC mixed rice husk ash was .20-.22.With the increase of the substitution rate of rice husk ash, the shrinkage of rice husk ash decreased and the change of rice husk ash decreased with the increased of age ,and the resistance to chloride ion permeation decreased. It was recommended to

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select RPC that appropriate replacement rate of rice husk ash according to different performance requirements.

5. R.yu et al. (2014) presents the mix design and properties assement of Ultra -High performance are Fiber Reinforced Concrete (UHPFRC). The design of the concrete mixtures is done to get a densely compacted cementitious matrix. The workability, porosity, air content, compressive and flexural strength of the designed UHPFRC are measured and analyzed. The results support the design UHPFRC with a relativity low binder amount by utilizing the improved packing model. The cement hydration degree of UHPFRC is calculated. And the results show that after 28 day of curing, there is still a large amount of unhydrated cement in the UHPFRC matrix, which could be further replaced by fillers to improve the workability and cost efficiency.
6. M K Maroliya. (volume 2, Issue 9, September 2012) An investigation on Reactive powder concrete containing steel fibers and Fly ash
7. Yin -Wen Chan, Shu-Hisen chu (2004) Effect of silica fume on steel fiber bond characteristic powder of reactive powder concrete.
8. Dr. Saravanal Sarika. p, Dr. Srinivas a Rao, Dr. Seshadri Sekhar T, Apparao. G (2013) Studies on Relationships between water /Binder ratio and compressive strength of high-volume fly ash concrete.
9. Smith M. Kachal, Ankur c. (2014) works on compressive strength of Cementous concrete containing used foundry sand and they are suggested replacement of natural sand by UFS provided an excellent improvement in basic strength property of concrete up to the replacement of 40%, the compressive strength was increased by 15%.
10. Zhu et al. (2016) made study on using recycled power from cement waste and waste of clay bricks in reactive powder concrete. Recycled powder obtained from waste of construction and demolition contains unhydrated cement particles. Use of recycled powder as a cementing material helps in reduction of environmental pollution. Study was made in RPC for replacing cement or silica fume by recycled powder for developing the environmentally friendly cost saving mixture of RPC of high performance. The RPC mix with the recycled powder was design reactive powder concrete were investigated.
11. H.M.A. I-Hassani et al. (2014) investigated some mechanical properties of Reactive powder concrete (RPC0.These properties include compressive strength, static modulus of elasticity, tensile strength (direct, splitting, and flexural), load -deflected capacity and flexural toughness. The variable parameters in the study where the silica fume, content (SF) as a partial replacement by weight of cement, steel fiber volume fraction and super plasticizer.
12. C.M. Tam et.al (2010) investigated mechanical and fresh concrete properties of reactive powder concrete, aiming to achieve the optimal conditions for producing reactive powder concrete using local materials by investigating the material composition, curing and heating regimes and microstructure of reactive powder concrete.
13. K.M. Ng et al. (2010) attempt to procedure reactive powder concrete using local materials under labraory conditions. Concrete designed form reactive powder concrete and high-performance concrete is experimentally conducted and compared. The result show that compressive strength, splitting tensile strength and static modulus of elasticity are found to be significantly higher than that of high-performance concrete using the same water -to-binder ratio.
14. Yang et.al. [2010] studied dynamic mechanical properties of Reactive powder concrete subjected to compressive impacts with high strain by means of SHPB (SPLIT -Hopkinson -Pressure-Bar) tests of the cylindrical specimens with five different steel fiber volumetric fractions.
15. Faizan Akbar, Fawad Bilal [2015] conducted research for design mix proportion of reactive powder concrete and compressive strength is computed. The samples were examined for the compressive strength of RPC design is effective way that would deliver RPC performance in terms of compressive strength/power. A total of 54 cubes 150 x150 x 150 mm were prepared. The samples were treated with plain water and hot water. The w-b ratio and content of ingredient were also kept altering, for better understanding. As a result of the all test performed combining concentrations with high silica content and low concentration of water yields good results.

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16. N. Roux [1996] an experimental study is conducted on durability of reactive powder concretes. The toughness of reactive powder concrete (RPC) is determined by measuring air permeability, water absorption, porosity and accelerated carbonation, chloride ions migration, solid corrosion resistance, resistance to mechanical absorption. The differentiation of results were done with M30 grade features Mpa concrete with less cement content and grade M80 Mpa very high-performance concrete.

III. MATERIAL DETAILING

Materials: - The materials used in this study were cement, Fine aggregate, Silica fume, Quartzite powder , Steel fibres , Nano silica ,High -range water reducer and water.

1. CEMENT: -

A powdery substance made by calcining lime and clay mixed with water to form mortar or mixed with sand gravel and water to make concrete. Basically, it is known as binding materials. Here used OPC53 grade concrete cement is require to conform to Bis specification IS:12269-1987 with a designed strength for 28 days being a minimum of 53 Mpa or 530 kg/sqcm.53 Grade provides high strength and durability to structure because of its optimum particle size distribution and superior crystallized structure.

CEMENT

CHEMICAL PROPERTIES: -

Main chemical compounds of Opc: - C3S, C3A, C4AF, C2S

SAND: Natural river bed or crushed sand of particle size are used. The particle size are taken 150 to 600 micron. It should be good for hardness and readily available at low cost.

SAND

FLY ASH: - It is one of the residues generated in combustion and comprises the fine particles that rise with the flue gases.

FLY ASH

QUARTZITE POWDER: **-** Quartzite Powder is available in crystalline form. It is selected based on its fineness. The particle size should be 5 microns to 25 microns. The main function of quartz is to give maximum resistance to the concrete against heat.

Quartzite powder

SUPER PLASTICIZER: **-** Polyacrylate is used as super plasticizer in RPC.The main function of polyacrylate is to decreased the water cement ratio and also to improve the workability of concrete.

Super plasticizer

STEEL FIBER: -Steel fibres of length 13 to 25 mm and 0.15 to 0.2 mm diameter are selected to prepare reactive powder concrete. It improves ductility of the concrete.

Pic :- Micro steel fiber

STEEL FIBER

SILICA FUME: **-** Silica fume is generally obtained from ferrosilicon industries. It should be selected in such a way that it should such a way that it should contain less quantity of impurities in it. The particle size of silica fume is about 0.1 micron to 1 micron. It is the function to fill the small voids and also to enhance flow properties of concrete.

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NANO SILICA : -It is purpose to produce a filler effect that is to fill in gaps and consequently, increase the compactness of the concrete. It is improved final compressive strength and reduce permeability. Reduces bleeding and segregation of concrete mixes, improves cohesion.

NANO SILICA

MATERIAL USED	DESIGNATION
Cement	Ordinary Portland cement of 53 grade conforming IS269:2015
Fine Aggregate	River sand conforming Zone II AS PER IS 383:1970
Coarse Aggregate	Single sized aggregate of nominal sized below 10mm conforming IS 383:1970
Steel fibre	Micro steel fibre used
Chemical admixture	Poly carboxylic ether
Water	Running portable water

Table of material Orientation

COMPONENTS	SELECTION	FUNCTION PARAMETERS	PARTICLE	TYPE
Sand	Good hardness Readily available at low cost.	Give strength Aggregate	150 micro meter -600 micro meter.	Natural crushed
Cement	C3S:60% C2S: 22% C3A:3.8% C4AF:7.4%	Binding material production of primary hydrates	1micro meter-100micro meter.	Opc medium fineness
Quartzite power	Fineness	Maximum reacting during heat treating	5 micro meters to 25 micro meters.	Crystalline
Fly ash	Cost effective	Improve workability of plastic concrete	10-100 micron	Silt size particle
Silica fume	Very less quantity of impurities	Filling the voids, enhances rheology, production of secondary hydrated	0.1micro meter to 1micro meter.	Procured from Ferro-silicon industry (highly refined)
Steel fiber	Good aspect ratio	Improve ductility	L;13-25mm	Straight

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			Dia:0.15-.2mm	
Super plasticizer	Less retarding characteristics	Reduce w/c	--------	Polyacrylate based

Binder content :- 900 kg/m³													
Sl no	**Cement Kg/m 3**	**Silica fume**	**Fly ash**	**Quartzite powder**	**water**	**Fine aggregate**	**Coarse aggregate**	**superplasticizer**	**Micro steel fiber**	**W/B**	**%of sp**		
	80	**5**	**15**	**0**	**190**	**550**	**800**	**20**	**115**	**0.2**	**2.0**		
1	**70**	**5**	**25**	**0**	**190**	**550**	**800**	**20**	**115**	**0.2**	**2.0**		
	60	**5**	**35**	**0**	**190**	**550**	**800**	**20**	**115**	**0.2**	**2.0**		
	70	**5**	**10**	**15**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
2	**60**	**5**	**15**	**20**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
	50	**5**	**20**	**25**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
	60	**5**	**15**	**20**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
3	**50**	**5**	**20**	**25**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
	40	**5**	**25**	**30**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
	60	**5**	**20**	**15**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
4	**60**	**5**	**25**	**10**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		
	60	**5**	**30**	**5**	**190**	**550**	**800**	**20**	**115**	**.2**	**2.0**		

IV. METHODOLOGY

Test procedure:- The main objective of this experimental study is to investigate the effect of flyash on the compressive strength of concrete.fly ash are incorporated into the concrete mix at varying percentage of 0% to 10% increment.The mechanical strength menas of compressive strength test.The compressive stength of concrte are iilustrate at different ages of hardened concrete.

Batching and Mixing :- Concrete is two phase materials composite of cement,fine aggregate,coarse aggregate and water.To produce sound concrte,it is important to maintain the proper proportioning of fundamental constituents of concrte during the penetration .The concrete is prepared by volume batching of the portland pozzolona cement ,river ,sand, below 10 mm nominal size coarse aggregate and portable water.

The concrete mixing operation has been performed by properly hand mixing process.usually this type of mixing process is suitable to produce ultra high performance concrte.

During the dry mix process,the coarse aggregate and fine aggregate are primarily mixed together and only that the cement is introduce to the mix.This mix is primary mix due to reason of finding the normal strength 7 ,28 days.

1. After that,cement,silica fume,flyash,quartzite powder,G.G.B.S, coarse aggregate,river sand were taken and weight and then dry mixed for 2-5 min.
2. Then the dry mixture with waterand admixture was slowly added to the mixer and mixed up for 4min.
3. Then the still fiber was scattered or mixed up slowly and spreadly and mixed for 2 min.

TEST SPECIMEN:-

The concrete specimen was prepared using moulds of specific dimensions 70.6 mm X 70.6 mm X 70.6 mm.The mould was of metal.

CASTING AND COMPACTING :-

The concrete was placed into the mould immediately after making or preparing the mix and compaced using a tamping rod.A premixing process is carried out before preparing of concrete specimen as a layer of lubricant is applied over the inner surface of cube .Each cube are filled the fresh concrete in 3 layers .each and every layer was tamped very care fully so that there is no honey comb present in the specimen.carefully handled when seggregation and bleeding occurs during over tamped and concrete matrix.Laslty the outer surface of cube are finhed propely with the help of trowel and smooth surface is provided to the concrete specimen.

For each concrete batch total 4 cube of mould are prepared for analysis of compressive strength respectively.Cubes are kept in free place from additional moisture and vibration. The concrete secimen are demoulded after 24 hours or 48 hours .Each batch of concrete specimen are marked with cement paste by marker or grill painting colour or febric etc And then proceed for the curing process.

CURING:- After demoulding of the concrete specimen they are taken for the curing process.The ater chmber are fully filled the water and concrete specimen is fully submergerd into the water.After 7 days and 28 days the mould are taken out of the water and placed over a plastic sheet for drying in air.

V. RESULT AND DISCUSSION

Table 5.1:- Compressive strength in conventional concrete

Sl no	Materials	Compressive strength			Average compressive strength
		7days	14 days	28 days	
1.	Conventional concrete	12.9	21.5	30.4	7 days-20.8
2.	Conventional concrete	20.5	27.2	29.2	14 days- 26
3.	Conventional concrete	26.5	28.3	32	28 days-32

Table 5.2 Compressive strength of concrete with different percentage of fly ash

SL NO	MATERIALS	%of cement replacement	%of fly ash replacement	COMPRESSIVE STRENGTH (N/mm^2)		
				7days	14days	28 days
1.	RPC1 - A 1 A2 A 3 A 4	80%	0%	5.00 15.0 12.5 12.2	9.00 17 14.4 18.2	15.19 26.5 20.9 24.00
2.	RPC2- B1 B2 B3 B4	75%	10%	23.30 22.65 26.55 30.85	35.45 42.6 39.62 40.0	50.39 52.24 46.08 45.09
4	RPC 4 D 1 D2 D3 D4	65%	20%	72.60 85.04 84.00 82.98	74.5 88.56 89.4 86.70	79.5 92 92.8 91.54
5	RPC(5) E 1 E2 E 3 E 4	60%	25%	85.0 91.9 88.23 87.65	88.33 93.5 90.58 88.89	92 94.32 98.55 105.02

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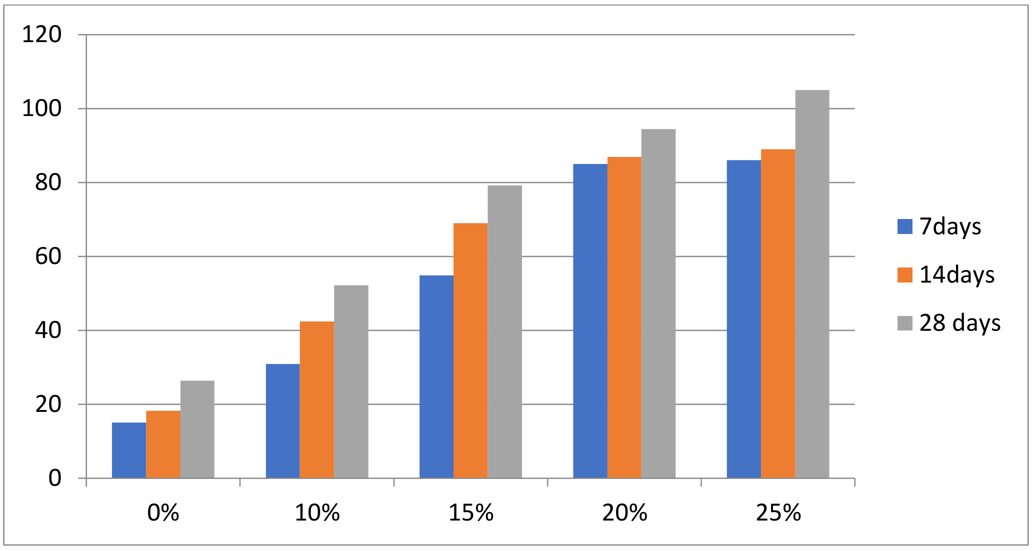
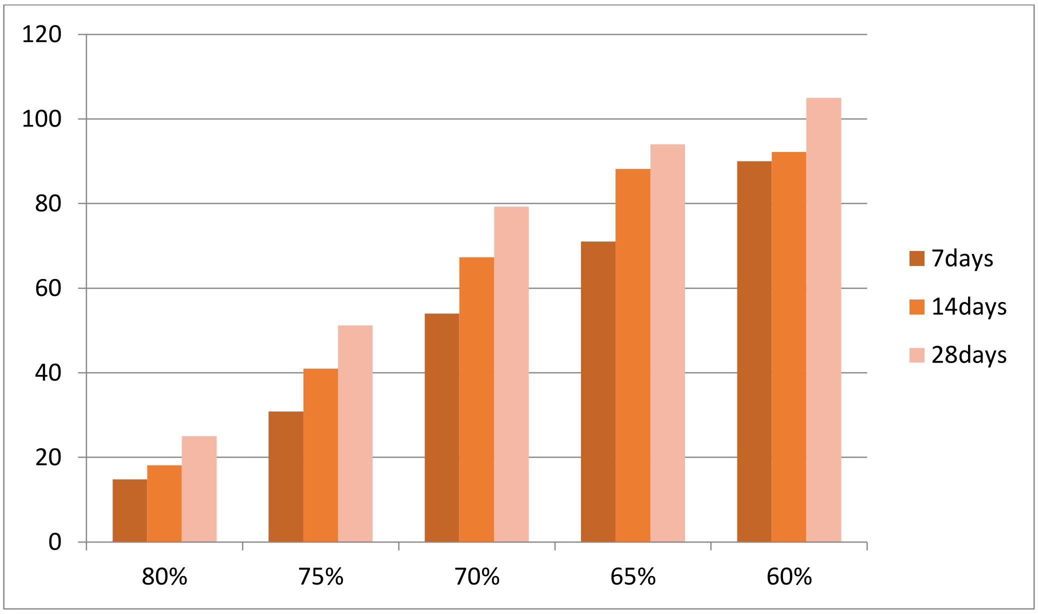
Different %of fly ash replacement



Different %of concrete replacement



VI. CONCLUSION

1. Here is special bonding between reactive powder concrete and flyash. Due to fly ash mixing with concrete compressive strength is increased in Reactive powder concrete.
2. Present of micro steel fibre the durability is more in Reactive powder concrete.
3. I want to see that applying various material in RPC the how much strength is achieved and it's really achieved near about 142 Mpa.

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