CURRENT JAPANESE ACTIVITY IN CFRTP FOR INDUSTRIAL APPLICATION

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ABSTRACT

Japanese CFRTP researches are going to rush into the next stage. Some research centers for CFRTP were established in the past few years, and new national project aiming to pursue multifunctional and ultra-lightweight automobile (2013-2022fy) started. This paper introduces such current Japanese activities.

WHAT IS HAPPENING IN JAPAN?

The University of Tokyo has organized Japanese national project to develop CFRTP for mass production automobile from 2008 to 2012fy [1]. In a meanwhile, a lot of groups which are interested in CFRP have been appeared as shown in Figure 1, and among them research centers for composite materials, in especially for CFRTP, have been established in the only past few years as shown in Table 1.

The background of this bubbly investment is sure to be the awareness of automotive manufacturers. They have applied ultra-lightweight technology only to the special automobile to supply extreme driving performance, but nowadays they have faced to the social demand for developing mass production electric vehicle and ultra-lightweight vehicle to mitigate the global oil consumption and CO_2 emission (see Table 2). Simultaneously, they have to adapt new social demand such as personal vehicle and more and more safety vehicle. For example, US-IIHS (insurance institute for highway safety) is going to ask automotive company to make automobile safer in the case of 25% offset front collision. It does not only make automobile heavier, but also will force automotive structure to change.

Therefore, new Japanese national project (2013-2022fy) started to develop technologies that can make us respond quickly to such demands of design changes, and pursue multifunctional and ultra-lightweight automobile by using CFRTP (see Figure 2). Including 3 CF manufacturers (Toray, Toho Tenax and Mitsubishi Rayon whose total world CF production share is about 60% as shown in Figure 3) and 5 automobile companies (Toyota, Nissan, Honda, Suzuki and Mitsubishi Motors whose total world passenger automobile production share is about 27% as shown in Figure 4), 22 companies, 5 public institutes and 7 universities participate in this project. While materials, structure and manufacturing techniques are going to be developed, wide range of CAE technologies are also going to be developed concerning material design, structural design and molding simulation (see Figure 5).

PURPOSE OF THE NEW NATIONAL PROJECT

The former national project has verified the potential of CFRTP whether the cost target of passenger automobile shown in Figure 6 can be achieved or not. Hence we have focused on the material development and high-cycle molding/welding while making clear their mechanisms (see Figures 7-16 and Table 3). Based on the results, the new national project is aiming to develop the following technologies.

(1) Design by/of CFRTP:

The former project has verified the applicability of CFRTP by making individual automotive parts with the same shape of steel ones as shown in Figure 15. But it is obviously not the best way of CFRTP usage. Hence structural design for both multi-materials and all-composite automobiles will be investigated in the new project. And new materials will be developed by the requests from design and manufacturing groups as shown in Figure 5.

(2) High-cycle manufacturing:

The former project has individually investigated resin impregnation, parts molding and their welding, but the new project will aim to find an integrated optimal manufacturing process applicable to factory production.

(3) Market waste recycling:

The former project developed some ways to make automotive parts by using in-plant CFRTP waste, but the new project will find the way to make automotive parts by using market CFRTP waste (see Figure 16).

REFERENCES

1. J. Takahashi, K. Uzawa and T. Matsuo, "Strategies and Technological Challenges for Realizing Lightweight Mass Production Automobile by using CFRTP", Proceedings of JISSE12, No.PL-3, (2011-11).

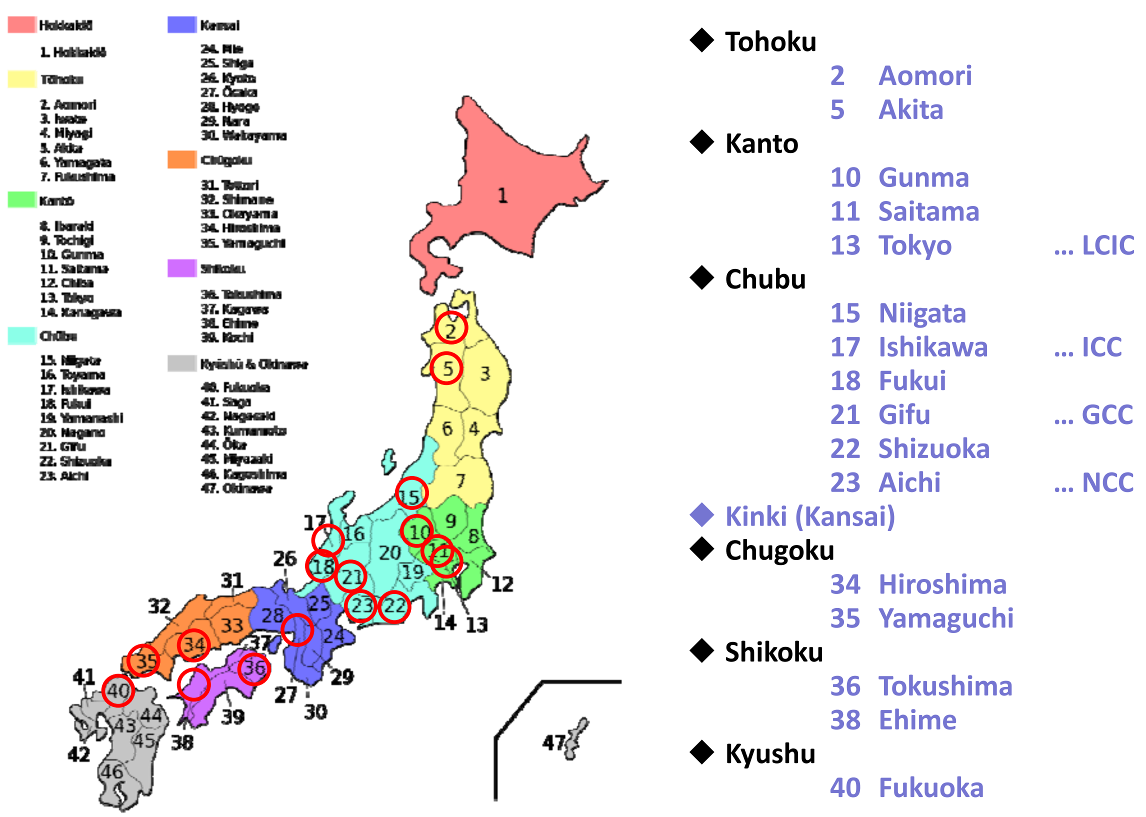


Figure 1 Japanese regions and prefectures promoting CFRP.

Table 1 Recent established Japanese research centers for composite materials.

Since	Name	Full name	Location	Key persons
2009 July	LCIC	Low Carbon Engineering Innovation Center	The University of Tokyo	Kazuro Kageyama Jun Takahashi
2012 April	NCC	National Composite Center	Nagoya University	Takashi Ishikawa
2012 April	GCC	Gifu University Composite Materials Center	Gifu University	Takushi Miyake Asami Nakai
2012 August	ICC	Ishikawa Carbon Fiber Cluster	Kanazawa Institute of Technology	Isao Kimpara Kiyoshi Uzawa

Table 2 Expectations for CFRTP (similarities and differences between airplane and automotive application).

		Airplane	Automobile
Motivation		high oil price → tight national budget (including military budget) → low-cost CFRP (<50€/kg) and maintenance	high oil prices and CO_2 measures → weight lightening & early spread of EV (by battery reduction) → low-cost CFRP (<10€) and recycling
Direction of technology development	Material & Preform	low-cost engineering plastics	low-cost & productive CF low-cost general-purpose resin low-cost impregnation
	Molding	low-cost manufacturing →from hours to minutes →thermoforming/welding yield improvement →automatic tape placement measures for labor costs and intellectual property → automation	low-cost manufacturing →less than one minute →thermoforming/welding yield improvement →recycling of in-plant waste measures for labor costs and intellectual property → automation
	Operation	repairability impact resistance simplification of NDI	repairability recyclability of market waste new design for dynamic social demand

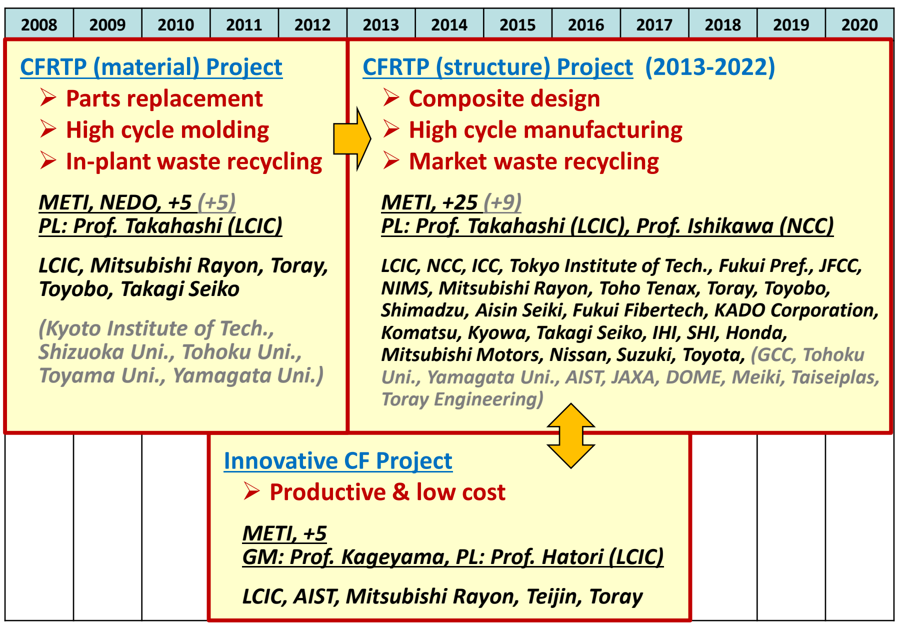


Figure 2 Japanese national projects for mass production CFRP automobile.

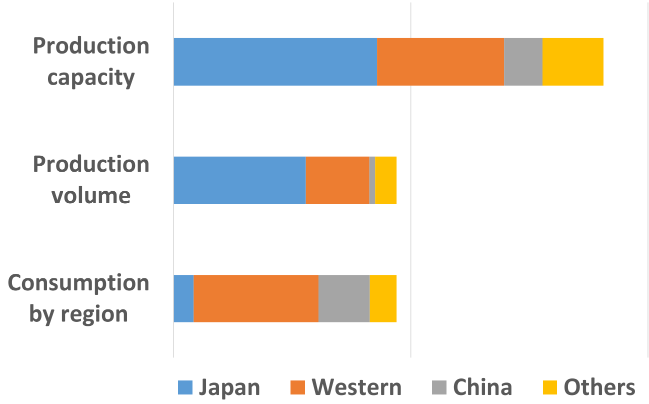
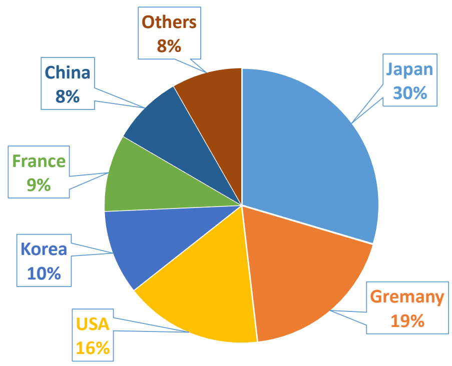


Figure 3   World carbon fiber share by production and consumption (2012).



World production share	
Toyota	11%
Nissan	6%
Honda	5%
Suzuki	4%
Mazda	2%
Mitsubishi	2%
Subaru	1%

Figure 4   World passenger automobile production share by country (2011).

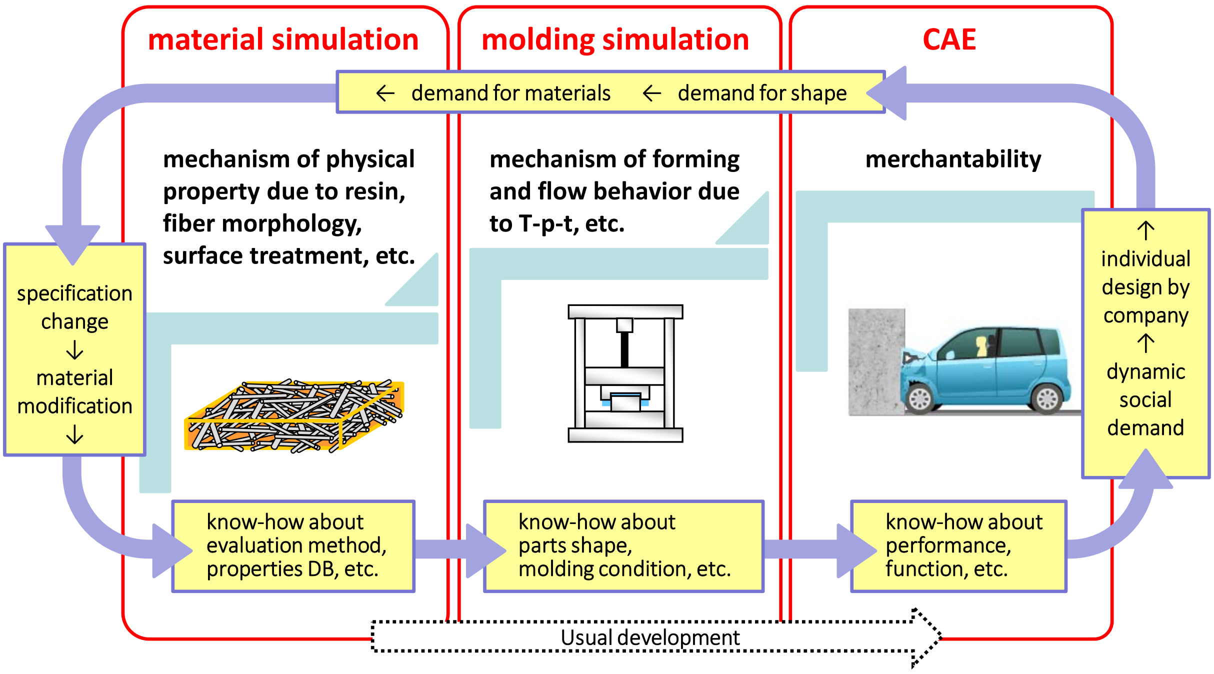


Figure 5   Systematic research and development of CFRTP technologies for mass production automobile in LCIC and NCC.

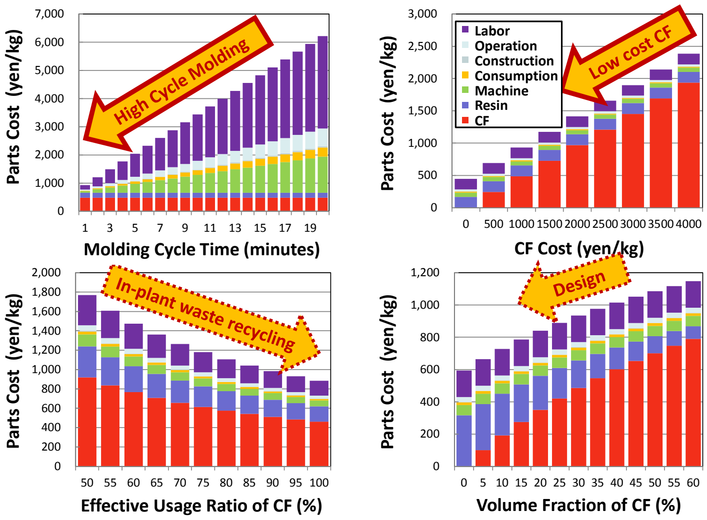


Figure 6 Effective cost reduction methods of CFRTP parts.

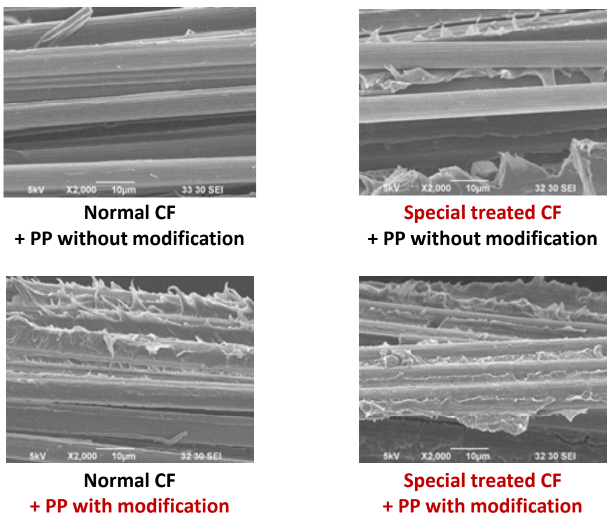


Figure 7 Modification of both CF and PP to improve adhesion.

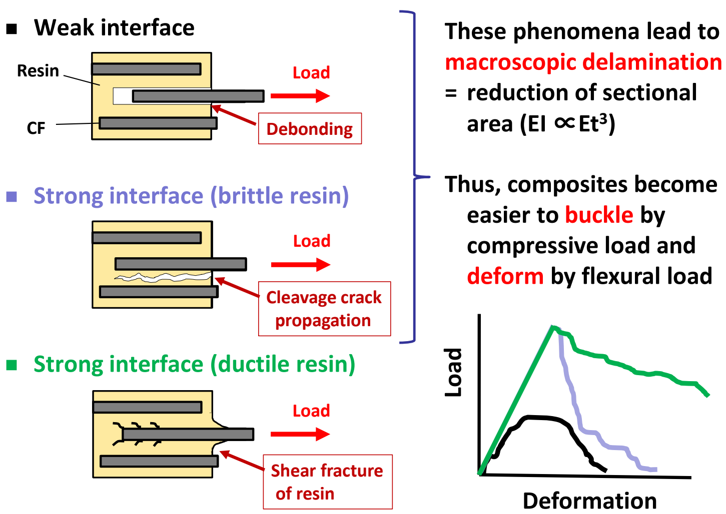


Figure 8 Difference in fracture process of composite materials.

Table 3 Differences in jointed and curved section between CFRTS and CFRTP.

	Thermosetting CFRP	Thermoplastic CFRP
Bonding joints	Adhesive joint × disassembly ○ workability △ reliability → facility become larger due to the integrated molding	Welding joint △ disassembly ○ affordable, easy, fast (a few seconds) ○ joint section is stronger than base material → mold small parts affordably, and assembly by welding joint technique !!
Bolted joints	○ disassembly × delamination when drilling × fiber cut, stress concentration → measures like metal insert → increase in weight, manufacturing time, and cost	○ disassembly ○ no delamination when drilling △ fiber is cut, stress is concentrated, but fracture is ductile → measures like insert are not necessary → reduction in weight, manufacturing time, and cost → applicable to joints with metal, and reliable parts
Curved section	× measures for stress concentration and delamination are necessary → structure becomes thick, complex and heavy	○ design is similar to metal ○ possibility of new high cycle molding methods utilizing the high workability → structure becomes simpler, lighter-weight, and affordable !!

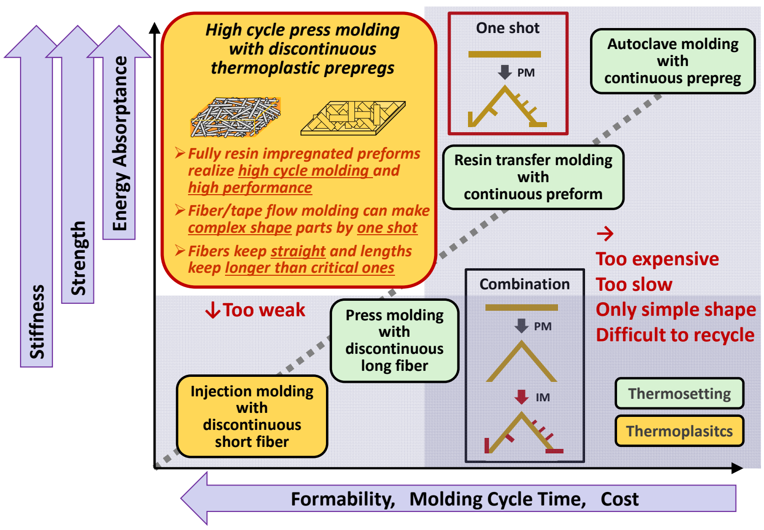
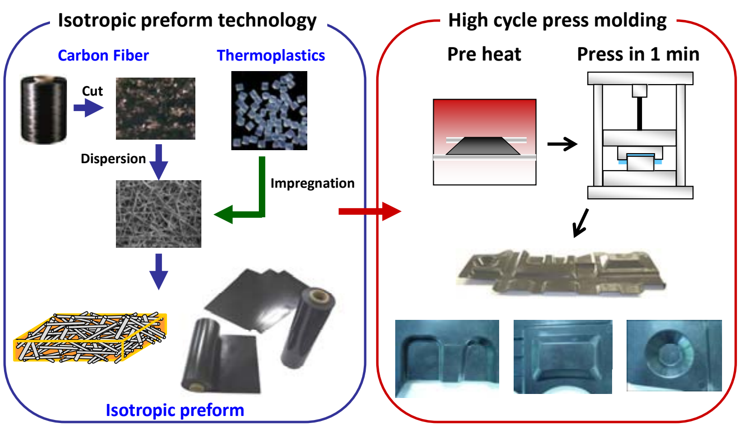


Figure 9 Developing direction of CFRTP for mass production.



*** It has been developed by Toray and Takagi Seiko.***

Figure 10 Discontinuous CF reinforced thermoplastics prepreg sheet.

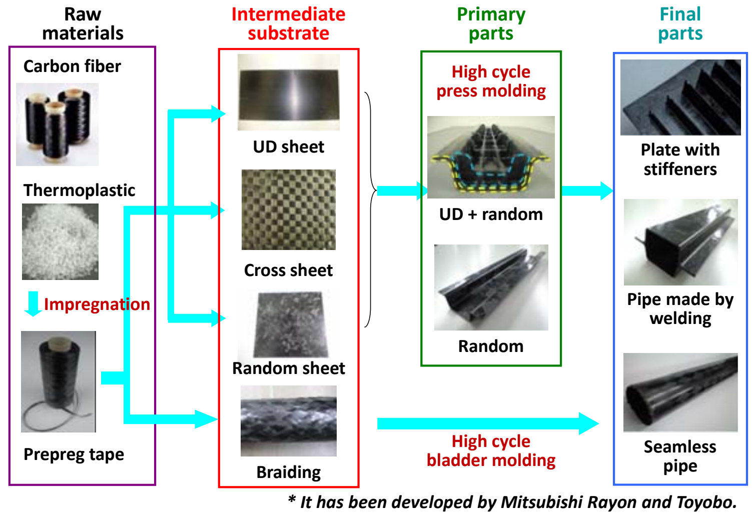


Figure 11   Continuous CF reinforced UD-tape and its various applications.

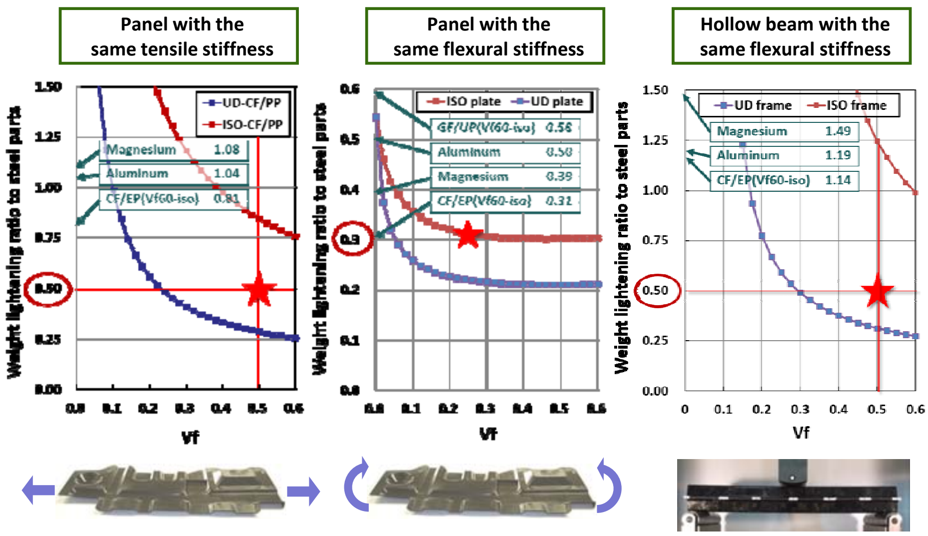


Figure 12   Several comparisons of weight lightening ratio between CF/PP and steel parts.

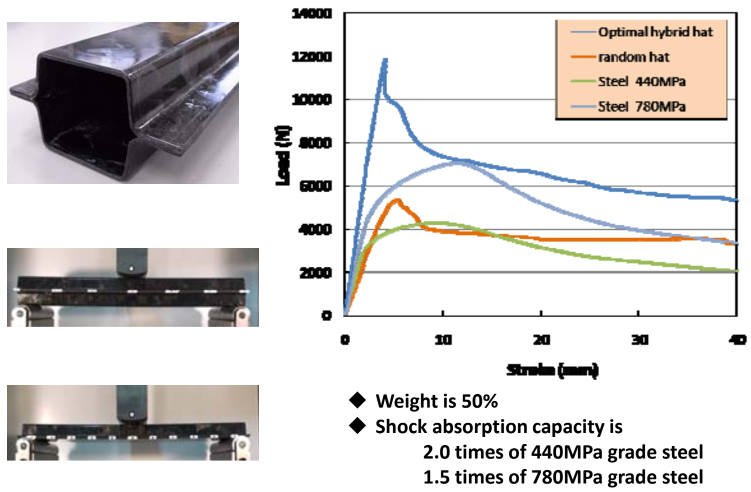


Figure 13   Comparison between CFRTP and steel hollow beam with the same flexural stiffness.

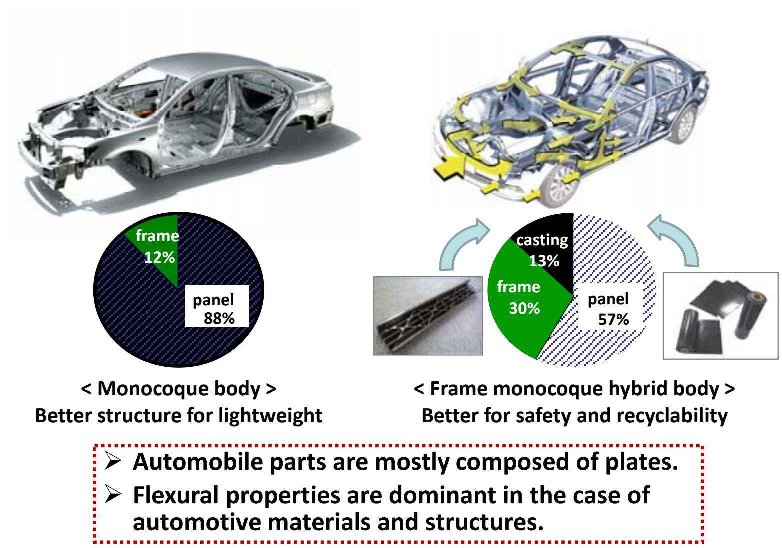


Figure 14 Automotive materials and structures.

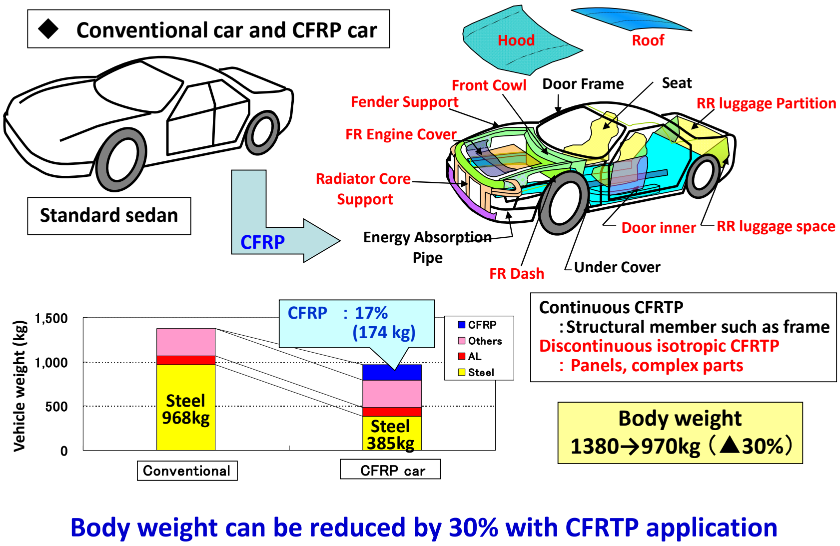


Figure 15 Weight reduction concept by parts replacement using CFRTP.

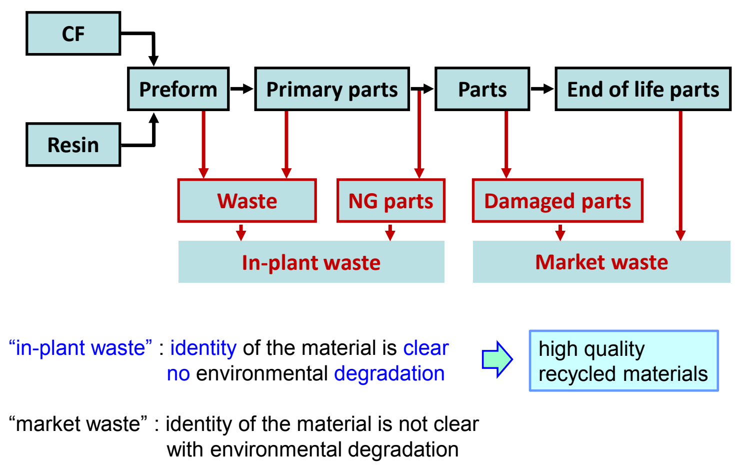


Figure 16 Difference between "in-plant waste" and "market waste".