C⁴S Research and Development Project

I. Development of reaction control technology and component manufacturing principles for CCC

The University of Tokyo・Taiheiyo cement company
・Tokyo University of Science

Presenter : The University of Tokyo
PM： Dr. NOGUCHI Takafumi, The University of Tokyo
Implementing organizations : The University of Tokyo, Hokkaido University

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Goal at 2029

In the pilot demonstration (construction of a house), it shall be confirmed that the structural performance, such as strength, etc., is equivalent to or higher than that of conventional concrete.

Development items

✓Development of technology to precipitate calcium carbonate between particles and make them solid

✓For precipitation, temperature control, pH control, and evaporation process control are examined in parallel and optimized process will be selected.

✓Raw material characterization, reaction process analysis, and material performance evaluation will be conducted to promote high performance. 。

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Results

1． CCC Production by temperature control：

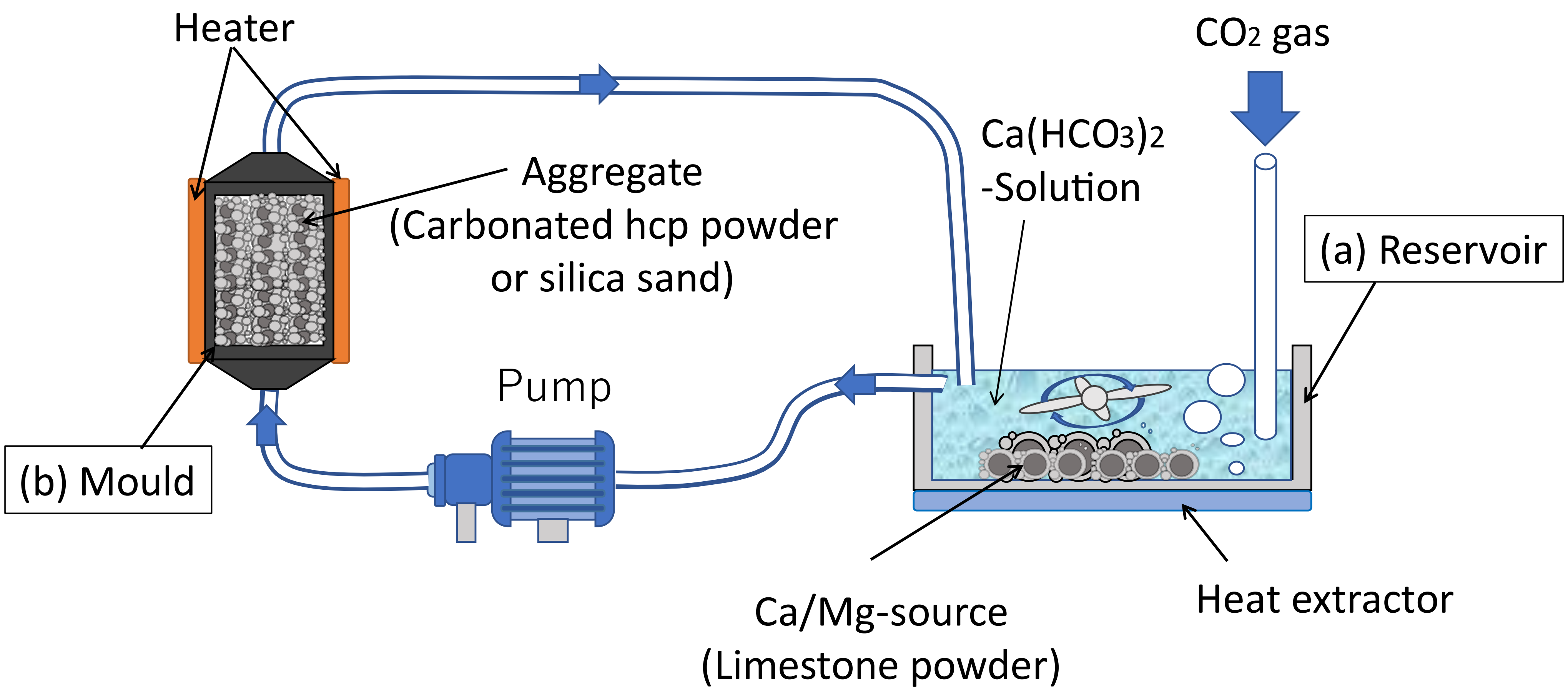

Fig. 1 Schematic of processing

For efficient production：
①Solution concentration analysis, ②Impact of particle size distribution, ③Temperature control, ④Heating conditions, ⑤Strength development mechanisms

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Results

1． CCC Production by temperature control：

Current state：ϕ10ｘ20㎜、 14MPa

ϕ50ｘ100㎜、 4.2MPa

Fig. 2 Current status of CCC specimen with different size

Eight-month after the starting of the project, ϕ50ｘ100㎜ specimen can be produced, The strength improvement is required.

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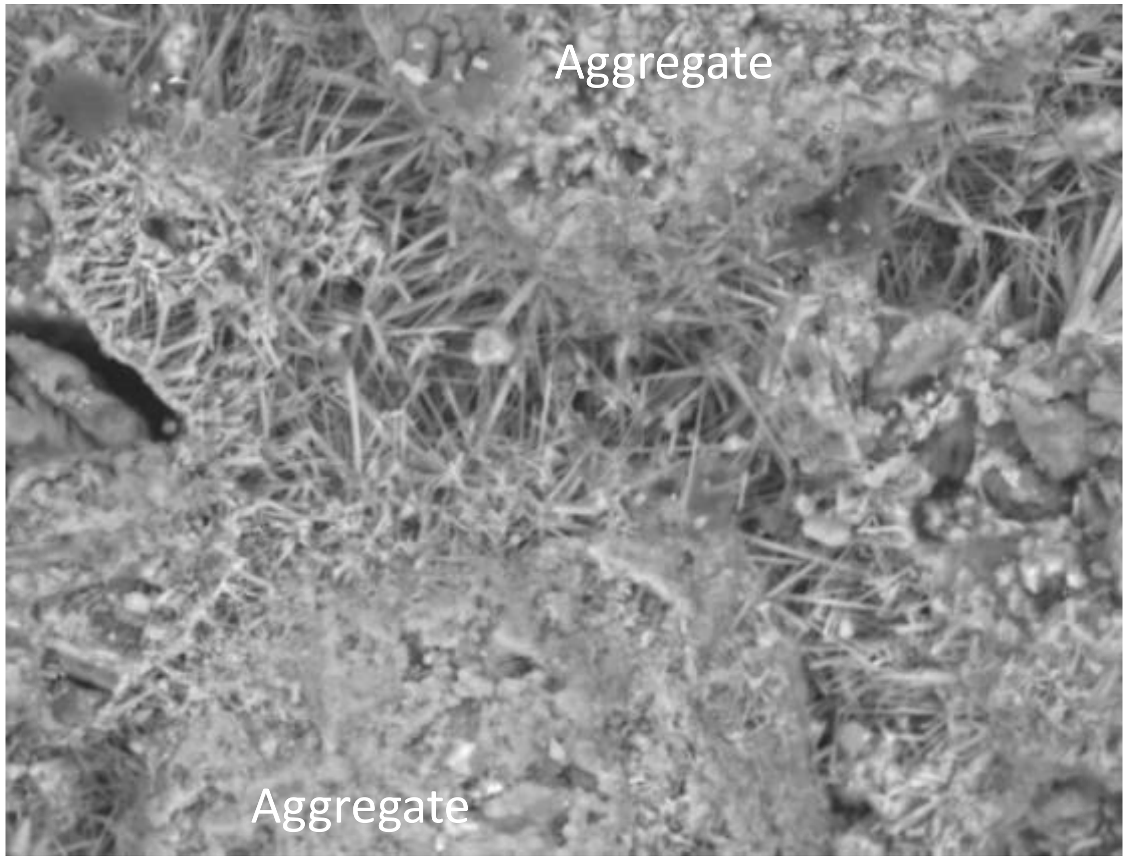

図３　試験体破断面の操作電子顕微鏡画像

Aggregate (Crushed hardened cement paste) surface covered by calcite. Aragonite formed on the top of the calcite. This aragonite bridge the particles and contributed to the strength development.

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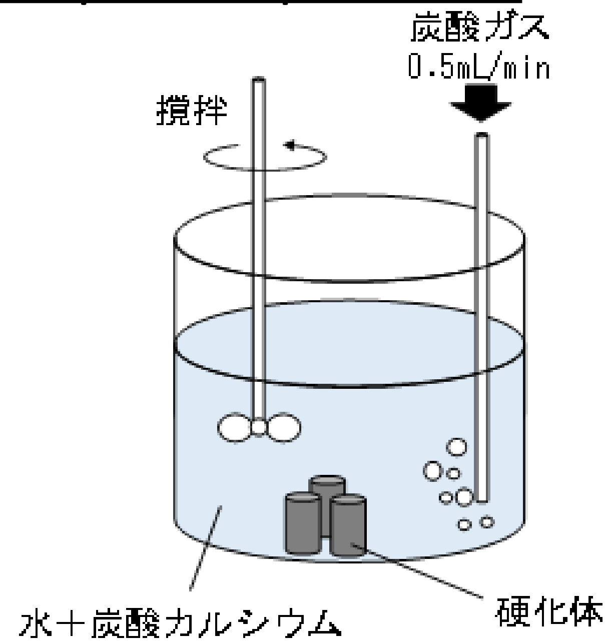
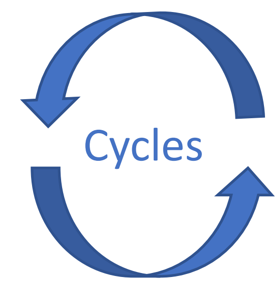
2． CCC Production by evaporation：

Fig. 4 Compaction process

Precipitaton process 1



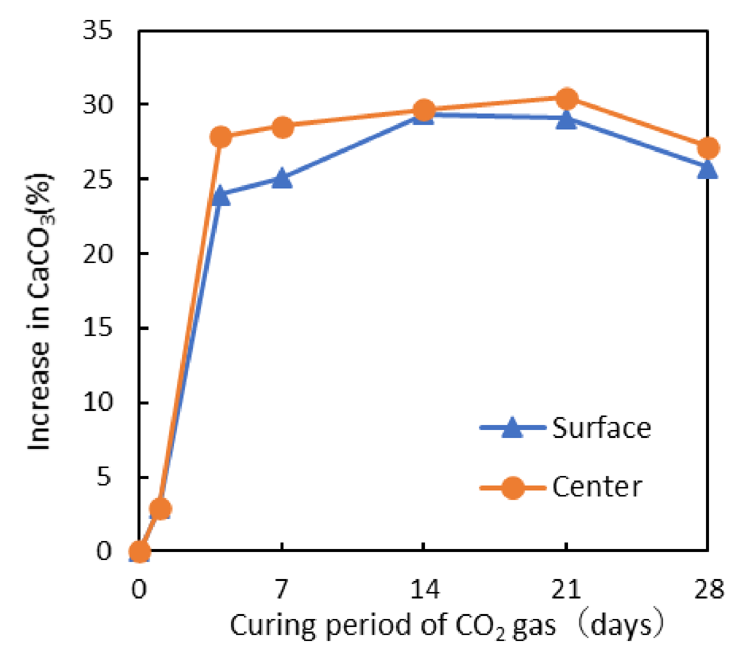
Dipped in bicarbonate solution (2 h)



105 degC oven (>12 h)

Precipitation process 2

CO2 gas curing (45℃-80%R.H.-$CO_2$80%)



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Results

2． CCC Production by evaporation：

Proportion of non-carbonated powder Grain size (mm) <0.3	<0.6	<1.2	Water (%)	Density (g/cm³) Demolding	Curing Period (days)	Density (g/cm³) Testing	Packing Ratio (%)	Compressive Strength (N/mm²)
25	50	25	15	1.68	28	1.62	68	**9.93**

Fig. 5 Loading process

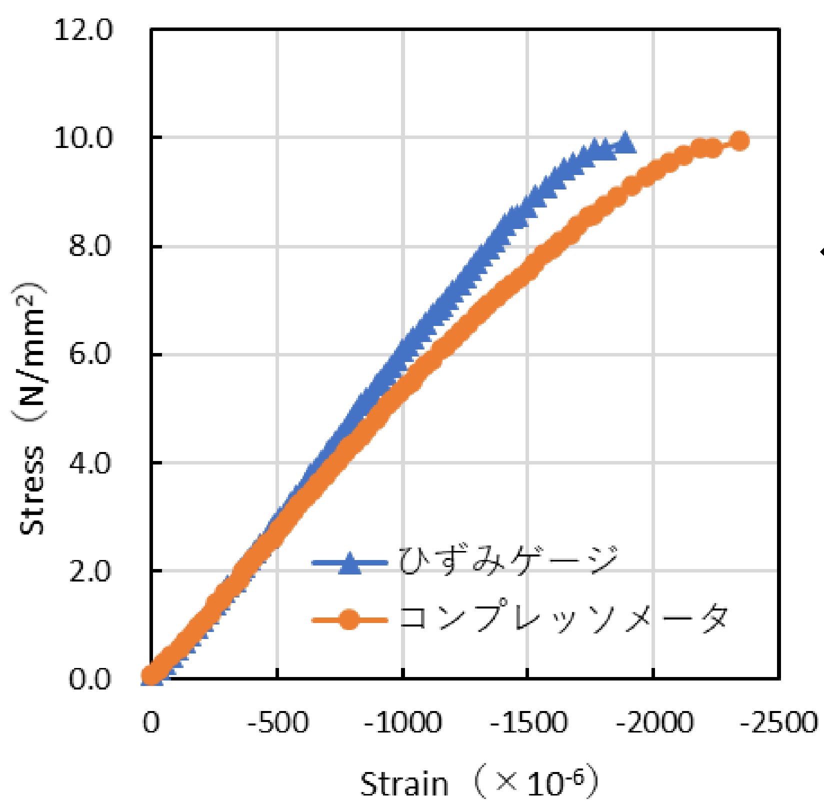

Fig. 6 Stress-strain relationship

◆Young’s modulus（JIS A1149）
- Strain guage：5.84kN/mm²
- Compresso-meter：5.44kN/mm²

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Summary

Currently, two different processes are being used to produce hardened specimens, and we are working to increase the size of the test specimens and the strength of the hardened specimens. With the understanding of the strength development mechanism, we will continue our research and development to achieve a strength of 12MPa by the end of FY2022.

C⁴S Research and Development Project

III. Development of structural design method, performance evaluation method for CCC buildings, and social implementation of C⁴S

Presenter : The University of Tokyo
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III. Development of structural design method, performance evaluation method for CCC buildings, and social implementation of C^4S

Goals at 2029

Develop data for obtaining the Minister of Land, Infrastructure, Transport and Tourism's approval for structural. After preparing data for the review of the system related to Article 37 (designated building materials) of the Building Standards Law, the system will be revised. Obtain approval from the Minister of Land, Infrastructure, Transport and Tourism for designated building materials. JIS for CCC will be established so that CCC can be used in civil engineering structures without any problems.

Content

✓CO2 emission reduction analysis
✓Resource Circulation Scenario Design
✓Material design method and structural design method
✓Implementation scenario of CCC structures

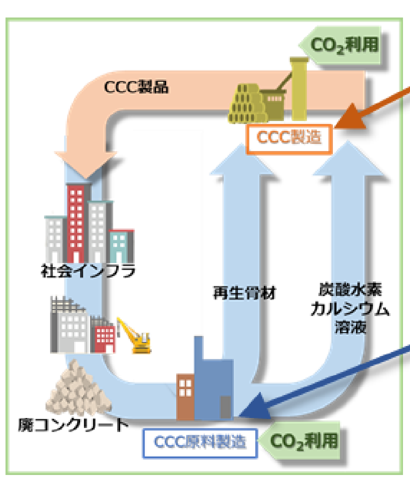
III. Development of structural design method, performance evaluation method for CCC buildings, and social implementation of C4S

CO2 emission reduction analysis

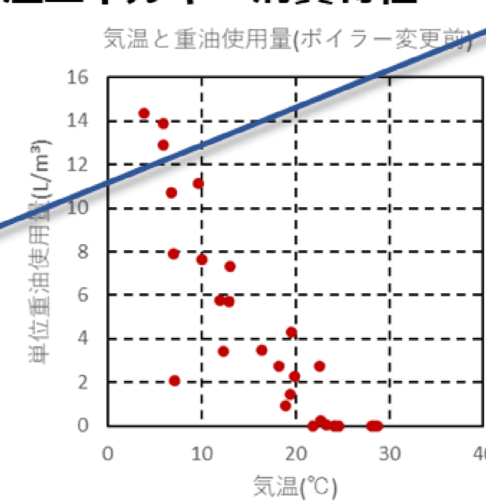
In addition to measuring the power consumption of the current experimental equipment, we are measuring the power consumption of similar actual structures to confirm/calculate the effect of CO_2 emission reduction.

2021年度の実施項目（当初計画，実施中）	2021年度の実施項目（追加）
中間処理場における エネルギー消費特性、CO_2排出特性の把握 **CCC原材料製造**における破砕・分級プロセスと対応 プレキャストコンクリート工場における エネルギー消費特性、CO_2排出特性の把握 **CCC製造**における温度差生成プロセスと対応	**CCCの小型試作製造装置**における エネルギー消費の計測開始 （装置手配中、11月下旬開始） **LCIデータベースの収集** (加圧など計測が難しい製造法の検討)

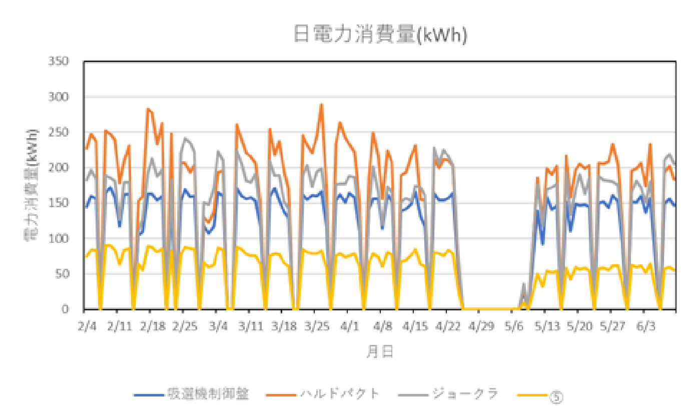
現在実施中の分析結果の例



プレキャストコンクリート工場の加温エネルギー消費特性



中間処理場のエネルギ消費特性（破砕・分級などプロセス別）

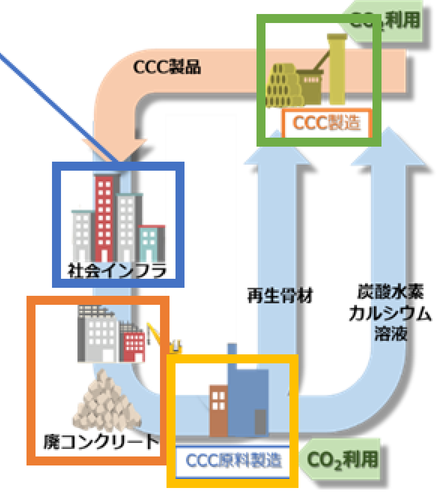


III. Development of structural design method, performance evaluation method for CCC buildings, and social implementation of C⁴S

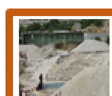
Resource Circulation Scenario Design

We have been conducting surveys / reviews based on various statistical data, such as statistics on building starts, building stock, and building dismantling. And we calculate the amount of concrete stock and its distribution in Japan.

①**現在の構造物ストック量**（m^2）
②**現在のコンクリート蓄積量**（m^3）
③**過去からのコンクリート累積量**（m^3）（路盤材等のリサイクル、埋戻し含む）
④構造物の寿命
⑤**将来のコンクリート廃棄物発生量**（m^3）

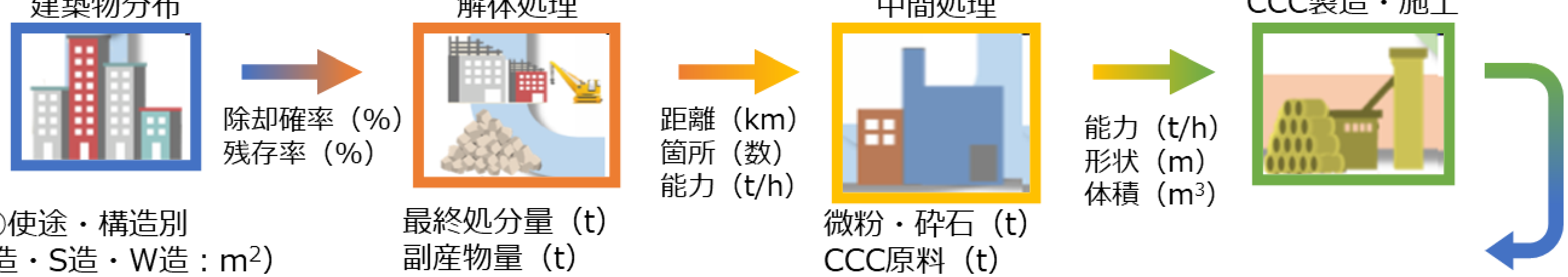


現在の建物ストック（民・公）　：約83億8187万m^2
現在のコンクリート蓄積量　：約34億2819万m^3、：約82億5890万t
住宅用　：非木造（35.1%）、木造（25.4%）
非住宅用：非木造（38.6%）、木造（0.2%）
＊ 原単位[生コンクリート0.41m^3/m^2、コンクリート密度2.4kg/m^3]



建築系コンクリート塊発生量：約27.0百万t（67%）
土木系コンクリート塊発生量：約13.5百万t（33%）

C⁴Sに適した中間処理施設・CCC原材料製造工場・CCC製造工場等の配置の検討



①②③使途・構造別（RC造・S造・W造：m^2）
最終処分量（t）
副産物量（t）
微粉・砕石（t）
CCC原料（t）

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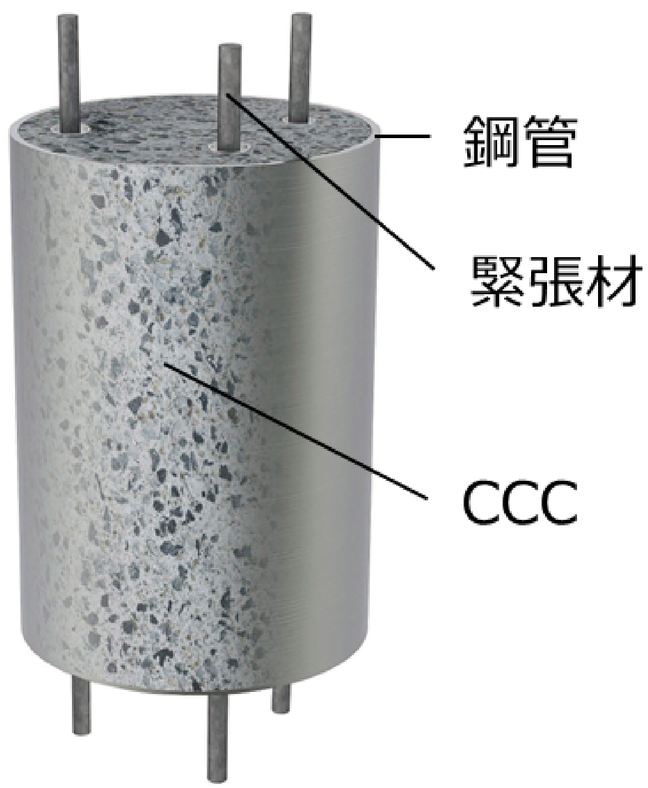
Material design method and structural design method

Proposing for structural forms are examined based on various current building construction methods and manufacturing methods.



◆想定構造形式の各スタディ
・ユニットの圧着積層方法
・長期荷重に対する安定性評価
・地震等の外力に対する安全性評価など

弾性係数
圧縮強度・引張強度など

拘束材（鋼管）の厚さ
緊張材の径・本数など

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Implementation scenario of CCC structures

Review of past processes for applying new materials based on literature review, interviews, etc.

年	CCCの開発・普及	CCC生産量	法律・規格の制定・改正
2023	12N/mm^{2}の圧縮強度達成	0 千t	
2025	実験構造物の建設	0.1 千t	
2030	低層CCC造建築物2～3棟の建設	2 千t	①**建築基準法第20条**に基づく大臣認定の取得
2040	毎年1.725倍増	345 千t	②日本建築学会規準・標準仕様書の制定 ③**建設省告示1446号**（技術的基準）の改正 ④**建築基準法第37条2項**に基づく大臣認定の取得 ⑤**日本産業規格（JIS）**の制定 ⑥**建設省告示1446号**（技術的基準）の改正 ⑦**建築基準法第37条1項**への適合
2050	コンクリート構造物の50%がCCC造	110,000 千t	

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM