

**SMLOUVA O ÚČASTI NA ŘEŠENÍ PROJEKTU
GAČR 26-23299S
MECHANO-CHEMICAL CARBONATION
FOR CEMENTING CO₂ IN CONCRETE**

Číslo smlouvy: Výzkumný ústav stavebních hmot, a.s.: 002/2026

Číslo smlouvy: Vysoká škola báňská – Technická univerzita Ostrava: S6/26-660-01

uzavřená dle ustanovení § 1746 odst. 2 zák. č. 89/2012 Sb., občanského zákoníku, ve znění pozdějších předpisů, a v souladu s příslušnými ustanoveními zákona č. 130/2002 Sb., o podpoře výzkumu, experimentálního vývoje a inovací z veřejných prostředků a o změně některých souvisejících zákonů (zákon o podpoře výzkumu a vývoje), ve znění pozdějších předpisů

Vysoká škola báňská – Technická univerzita Ostrava

Sídlem: 17. listopadu 2172/15, 708 00 Ostrava

IČ: 61989100

DIČ: CZ61989100

Bankovní spojení: 94-6225761/0710, vedený u ČNB

Zastoupená: prof. Ing. Igor Ivan, Ph.D. rektor

Odpovědný zaměstnanec za příjemce/hlavní řešitel: XXXXXXXXXX

dále též jako „příjemce“

a

Výzkumný ústav stavebních hmot, a.s

Zapsán v OR u KS v Brně, oddíl B, vložka 3470

Sídlem: Hněvkovského 30/65, Komárov, 617 00 Brno

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Zastoupená: Ing. Zdeněk Krejza, Ph.D., předseda správní rady

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Odpovědný zaměstnanec za dalšího příjemce/hlavní řešitel: XXXXXXXXXX

dále též jako „další účastník“

I.

Předmět smlouvy

1. Předmětem této smlouvy je stanovení podmínek spolupráce smluvních stran na řešení projektu základního výzkumu předloženého ve veřejné soutěži „Standardní projekty na rok 2026“ Grantové agentury České republiky.
2. Identifikace projektu:

Název: Mechano-chemical carbonation for cementing CO₂ in concrete

Reg. Č.: 26-23299S

II. Řešení projektu

1. Řešení projektu je rozloženo do období od 01/2026 do 12/2028.
2. Předmětem projektu je návrh a vývoj nové mechanochemicky akcelerované karbonizační metody, která umožní vysoce účinnou mineralizaci CO₂ v tuhých odpadech a následné využití karbonátovaných odpadů při výrobě nízkouhlíkových cementových kompozitů.
3. Cíle projektu:
 - Stanovit mechanismy mechanochemicky akcelerované karbonizace.
 - Objasnit aktivační mechanismus tuhých odpadů.
 - Vyvinout metodu mechanochemické aktivace a karbonace.
 - Navrhnout nízkouhlíkové cementové a betonové kompozity.
 - Charakterizovat mikrostrukturu a vlastnosti materiálů.
4. Předpokládané výsledky za celý projekt uvedené v Návrhu projektu:
min. 7 článků v časopisech Q1, z toho min. 4 články v D1.
1 odborná editovaná kniha formou sborníku.
5. Za řízení projektu je odpovědný příjemce.

III. Věcná náplň spolupráce příjemce a dalšího účastníka

1. Smluvní strany se za účelem naplnění předmětu smlouvy vymezeného výše zavazují spolupracovat tak, že zajistí spolupráci řešitele a dalšího řešitele (příp. dalších pověřených osob) na řešení úkolů v rámci projektu. Náplň řešení projektu spolu s podíly na řešených úkolech včetně odpovědností jednotlivých členů řešitelského týmu jsou podrobně specifikovány v Návrhu projektu, který je přílohou č. 1 k této smlouvě.

IV. Finanční zajištění projektu

1. Příjemce se na základě této smlouvy zavazuje dalšímu účastníku projektu převést za předpokladu jejich obdržení od poskytovatele na řešení výše uvedené věcné náplně projektu neinvestiční účelové finanční prostředky ve výši **3 531 000,- Kč**,
 - a to v roce 2026 ve výši 1 067 000,- Kč,
 - v roce 2027 ve výši 1 229 000,- Kč,
 - v roce 2028 ve výši 1 235 000,- Kč.
2. Účelové finanční prostředky je příjemce povinen dalšímu účastníku projektu uhradit vždy bezhotovostním převodem na jeho bankovní účet uvedený v záhlaví smlouvy nejpozději do 30 dnů od obdržení účelových prostředků od poskytovatele.
3. V případě, že poskytovatel rozhodne o poskytnutí odlišné částky na řešení projektu, než je uvedena v návrhu projektu, zavazují se smluvní strany upravit poměrně výši účelových prostředků dodatkem k této smlouvě.
4. Převáděné účelové finanční prostředky nejsou předmětem DPH.

5. Účelové finanční prostředky dle této smlouvy jsou příjemcem dalšímu účastníku projektu poskytovány na úhradu skutečně vynaložených provozních nákladů účelově vymezených touto smlouvou.
6. Rozpis grantových prostředků pro jednotlivé roky řešení:
- a) příjemce:

Náklady uchazeče dle nákladových kategorií					
Rok řešení		2026	2027	2028	Celkem
Věcné náklady	Kč	983 000	839 000	767 000	2 589 000
Investiční náklady	Kč	0	0	0	0
Osobní náklady	Kč	835 000	835 000	835 000	2 505 000
Celkové náklady	Kč	1 818 000	1 674 000	1 602 000	5 094 000
Dotace poskytovatele	%	100	100	100	100

b) další účastník

Náklady uchazeče dle nákladových kategorií					
Rok řešení		2026	2027	2028	Celkem
Věcné náklady	Kč	257 000	419 000	425 000	1 101 000
Investiční náklady	Kč	0	0	0	0
Osobní náklady	Kč	810 000	810 000	810 000	2 430 000
Celkové náklady	Kč	1 067 000	1 229 000	1 235 000	3 531 000
Dotace poskytovatele	%	100	100	100	100

V.

Podmínky použití poskytnutých účelových finančních prostředků

1. Další účastník projektu je povinen:
- Použít účelové finanční prostředky výhradně k úhradě prokazatelných, nezbytně nutných nákladů přímo souvisejících s plněním cílů a parametrů řešené části projektu, a to v souladu s podmínkami stanovenými obecně závaznými právními předpisy.
 - Vést o čerpání a užití účelových finančních prostředků poskytnutých na řešení projektu samostatnou účetní evidenci tak, aby tyto prostředky a nakládání s nimi bylo odděleno od ostatního majetku dalšího účastníka projektu. Tuto evidenci uchovávat po dobu 10 let od poskytnutí účelových finančních prostředků na řešení části projektu. Při vedení této účetní evidence je další účastník projektu povinen dodržovat obecně závazné právní předpisy, běžné účetní zvyklosti a příslušné závazné podmínky uvedené v zásadách, pokynech, směrnicích nebo v jiných předpisech uveřejněných ve Finančním zpravodaji Ministerstva financí, nebo jiným obdobným závazným způsobem.
 - Dosáhnout stanovených cílů a parametrů části projektu.
 - Předložit příjemci nejpozději do dne **15. 12.** kalendářního roku, ve kterém trvá řešení projektu, písemnou roční zprávu o realizaci části projektu v průběhu daného roku, resp. do **12. 1.** následujícího roku musí příjemci předložit podrobné vyúčtování hospodaření s poskytnutými účelovými finančními prostředky, návazně je další účastník projektu povinen vrátit příjemci do dne **31. 1.** daného kalendářního roku účelové finanční prostředky, které nebyly dalším účastníkem projektu dočerpány do konce kalendářního roku s tím, že vrácené účelové finanční prostředky budou příjemci avizovány předem a ten je povinen je následně do **15. 2.** vrátit do státního rozpočtu.

- e) V případě, že vznikne povinnost vrácení účelových finančních prostředků z jiných důvodů než na podkladě finančního vypořádání, je další účastník projektu povinen neprodleně písemně požádat příjemce o sdělení podmínek a způsobu vypořádání těchto prostředků.
- f) Umožnit poskytovateli a příjemci či jimi pověřeným osobám provádět komplexní kontrolu jak výsledků řešení projektu, tak i účetní evidence a použití účelových finančních prostředků, které byly na řešení části projektu poskytnuty ze státního rozpočtu, a to kdykoli v průběhu řešení projektu nebo do 10 let od ukončení poskytování finančních prostředků ze státního rozpočtu na část projektu. Tímto ujednáním nejsou dotčena ani omezena práva kontrolních a finančních orgánů státní správy České republiky.
- g) Postupovat při nakládání s účelovými finančními prostředky získanými na základě rozhodnutí poskytovatele a této smlouvy a s majetkem a právy za ně pořízenými v souladu s obecně závaznými právními předpisy týkajícími se hospodaření se státním majetkem (např. zák. č. 134/2016 Sb., o zadávání veřejných zakázek; zák. č. 218/2000 Sb., o rozpočtových pravidlech a o změně některých souvisejících zákonů, ve znění pozdějších předpisů).
- h) Informovat příjemce o případné své neschopnosti plnit řádně a včas povinnosti vyplývající pro něj z této smlouvy a o všech významných změnách svého majetkoprávního postavení, jakými jsou zejména vznik, spojení či rozdělení společnosti, změna právní formy, snížení základního kapitálu, vstup do likvidace, zahájení insolvenčního řízení, zánik příslušného oprávnění k činnosti apod., a to bezprostředně poté, co tyto změny nabydou právní platnost.
- i) Vrátit příjemci veškeré poskytnuté účelové finanční prostředky včetně majetkového prospěchu získaného v souvislosti s jejich použitím a to do 30 dnů ode dne, kdy oznámí, nebo kdy měl oznámit příjemci ve smyslu předchozího odstavce, že nastaly skutečnosti, na jejichž základě další účastník projektu nebude moci nadále plnit své povinnosti vyplývající pro něj z této smlouvy včetně příloh.
- j) Dodržovat další povinnosti, vyplývající z ustanovení Zadávací dokumentace „Standardní projekty - 2026“ Grantové agentury České republiky a rozhodnutí o poskytnutí dotace.

VI.

Práva k hmotnému majetku

1. Vlastníkem hmotného majetku, nutného k řešení projektu a pořízeného z poskytnutých účelových prostředků, je ta smluvní strana, která si uvedený majetek pořídila nebo ho při řešení projektu vytvořila. Byl-li tento majetek pořízen či vytvořen příjemcem a dalším účastníkem společně, je jejich podíl na vlastnictví tohoto majetku stejný, nedohodnou-li se jinak.
2. S majetkem, který další účastník projektu získá v přímé souvislosti s plněním cílů projektu a který pořídí z poskytnutých účelových finančních prostředků, není další účastník projektu oprávněn nakládat ve vztahu k třetím osobám v rozporu s touto smlouvou bez předchozího písemného souhlasu příjemce, a to až do doby úplného vyrovnaní všech závazků, které pro dalšího účastníka projektu vyplývají z této smlouvy.
3. Smluvní strany se zavazují zpřístupnit si vzájemně zařízení potřebná k řešení projektu vymezené v Návrhu projektu.

VII.

Ochrana duševního vlastnictví

1. Znalosti vkládané do projektu:
 - a) Vkládané znalosti zůstávají vlastnictvím strany, která je do projektu vložila.
 - b) Ostatní smluvní strany jsou oprávněny použít vkládané znalosti pro práce na projektu, pokud jsou nezbytně potřebné, po dobu trvání projektu zdarma.
 - c) Smluvní strany mají právo na nevýhradní licenci za tržních podmínek k vkládaným znalostem ve vlastnictví jiné strany, pokud je nezbytně potřebují pro využití vlastních výsledků projektu, protože bez nich by bylo užití vlastních výsledků technicky nebo právně nemožné. O licenci je třeba požádat do dvou let od skončení projektu.

- d) Smluvní strany nejsou oprávněny použít vkládané znalosti k jinému účelu a jiným způsobem, pokud si předem písemně nesjednají jinak zvláštní smlouvou.
- e) Smluvní strany používají vkládané znalosti druhé strany na vlastní nebezpečí a berou na vědomí, že jsou jim vkládané znalosti zpřístupněny bez jakékoli záruky, zejména, co se týče jejich správnosti, přesnosti a vhodnosti pro konkrétní účel. Smluvní strana, která vkládané znalosti jiné strany použije, je sama odpovědná za případná porušení práv duševního vlastnictví třetích osob.

VIII.

Práva k výsledkům a využití výsledků

1. Práva k výsledkům:
 - a) Výsledky projektu, kterých bude v rámci projektu dosaženo pouze jednou smluvní stranou, budou zcela ve vlastnictví té smluvní strany, která tyto výsledky vytvořila.
 - b) Výsledky projektu, které budou dosaženy v rámci projektu více stranami společně tak, že jednotlivé tvůrčí příspěvky smluvních stran nelze oddělit bez ztráty jejich podstaty, budou ve společném vlastnictví smluvních stran. Pokud nelze určit tvůrčí podíly jednotlivých smluvních stran na výsledku a strany se nedohodly jinak, platí, že jsou spoluvlastnické podíly rovné.
2. Využití výsledků:
 - a) Smluvní strana je oprávněna k nevýhradnímu užití výsledků ve vlastnictví druhé smluvní strany, pokud jsou nezbytné pro užívání výsledků projektu vlastněných touto smluvní stranou, za obvyklých tržních podmínek, o licenci je třeba požádat do dvou let od skončení projektu.
 - b) Výsledky ve společném vlastnictví smluvních stran je oprávněna samostatně užívat každá smluvní strana. Výsledek ve společném vlastnictví více smluvních stran je oprávněn používat ke komerčním účelům každý ze spoluvlastníků, je však povinen předtím uzavřít s ostatními spoluvlastníky smlouvu o využití předmětného výsledku, která stanoví způsob dělení příjmů z komerčního využití.
3. Ustanovení předchozích odstavců nebrání tomu, aby smluvní strany po vzájemné dohodě upravily vlastnická a užívací práva k výsledkům projektu v jednotlivých případech odlišně při respektování platné legislativy a podmínek projektu stanovených poskytovatelem.
4. Pokud se smluvní strany nedohodnou písemně jinak, uplatní se ustanovení tohoto článku obdobně na nároky k výsledkům projektu v případě předčasného ukončení smlouvy.

IX.

Odpovědnost a sankce

1. Pokud další účastník projektu použije účelové finanční prostředky v rozporu s účelem a/nebo k jinému účelu, než ke kterému mu byly dle této smlouvy příjemcem poskytnuty, či je bude jinak neoprávněně používat či zadržovat, ujednávají smluvní strany, že takové jednání bude pro účely této smlouvy považováno za porušení rozpočtové kázně ve smyslu ustanovení § 44 a násl. zákona č. 218/2000 Sb., o rozpočtových pravidlech a o změně některých souvisejících zákonů, ve znění pozdějších předpisů, a bude mít důsledky analogické důsledkům v tomto zákoně uvedeným.
2. Za každé závažné (podstatné) porušení povinností vyplývajících z této smlouvy je smluvní strana, která svou povinnost porušila, povinna uhradit druhé smluvní straně smluvní pokutu ve výši 0,05 % z celkové výše poskytnutých účelových finančních prostředků. Tímto ujednáním o smluvních sankcích není dotčeno právo smluvní strany na náhradu vzniklé škody, kterou je oprávněna vymáhat samostatně.

3. Pokud by došlo k porušení pravidel (podmínek) spolupráce vymezených v této smlouvě některou ze smluvních stran, je strana, která porušení způsobila, povinna nahradit druhé straně prokazatelnou škodu.

X.

Závěrečná ustanovení

1. Další účastník se bezvýhradně zavazuje, že se bude řídit smlouvou o poskytnutí podpory na řešení projektu uzavřenou mezi poskytovatelem a příjemcem, včetně všech jejích příloh. Další účastník je dále povinen poskytnout příjemci veškerou potřebnou součinnost za účelem dodržení povinností mu plynoucích ze smlouvy o poskytnutí podpory uzavřené s poskytovatelem.
2. Smluvní pokuty sjednané touto smlouvou nesaturují případný nárok poškozené strany na náhradu škody.
3. Zásady, které nejsou touto smlouvou upraveny, se řídí zákonem č. 89/2012 Sb., občanským zákoníkem, v platném znění, a právními předpisy na občanský zákoník pro účely této smlouvy navazujícími, a to zejména zákonem č. 130/2002 Sb., o podpoře výzkumu, experimentálního vývoje a inovací z veřejných prostředků a o změně některých souvisejících zákonů (zákon o podpoře výzkumu a vývoje), ve znění pozdějších předpisů.
4. Tuto smlouvu lze měnit pouze písemně, její změna v jiné formě je vyloučena.
5. Tato smlouva o vzájemných vztazích mezi příjemci se uzavírá s účinností od data zahájení řešení projektu nebo registrace v registru smluv, dle toho, která skutečnost nastane později, na dobu určitou do ukončení řešení projektu a vyrovnání všech závazků smluvních stran s tím souvisejících, avšak s výjimkou přežívajícího článku VII a VIII této smlouvy. V případě, že nebude poskytovatelem přiznána a poskytnuta podpora na řešení projektu a s řešením projektu tudíž nebude započato, tato smlouva nevstoupí v účinnost a její platnost automaticky skončí dnem zveřejněním rozhodnutí, resp. oznámení poskytovatele o nepřiznání podpory.
6. Kterákoliv smluvní strana může tuto smlouvu vypovědět. Výpovědní doba je v takovém případě dvouměsíční a její běh začíná prvním dnem měsíce následujícího po doručení výpovědi. Výpověď musí být učiněna v písemné formě, jinak je neplatná.
7. Smluvní strany berou na vědomí, že tato smlouva a její případné dodatky mohou být uveřejněny ve smyslu zákona č. 340/2015 Sb., o zvláštních podmínkách účinnosti některých smluv, uveřejňování těchto smluv a o registru smluv (zákon o registru smluv), neboť jsou je povinným subjektem dle citovaného zákona. Pro tyto případy se zavazují druhou smluvní stranu písemně upozornit na obchodní tajemství a jiné chráněné údaje vyplývající z této smlouvy nebo jejích dodatků, které má být anonymizováno.
8. Smlouva je vyhotovena ve třech (3) stejnopisech s platností originálu, z nichž každá smluvní strana obdrží jeden (1) stejnopis a jeden (1) stejnopis je určen pro potřeby poskytovatele. Smlouvu lze také podepsat elektronicky zaručenými podpisy.
9. Tato smlouva obsahuje úplné ujednání o předmětu smlouvy a všech náležitostech, které strany měly a chtěly ve smlouvě ujednat, a které považují za důležité pro závaznost této smlouvy. Žádný projev stran učiněný při jednání o této smlouvě ani projev učiněný po uzavření této smlouvy nesmí být vykládán v rozporu s výslovnými ustanoveními této smlouvy a nezakládá žádný závazek žádné ze stran.
10. Smluvní strany výslovně potvrzují, že tato smlouva je výsledkem jejich jednání a každá ze stran měla příležitost ovlivnit její základní podmínky.

11. Nedílnou součástí této smlouvy jsou přílohy:

P1 - Project Proposal (Návrh projektu číslo 26-23299S)

P2 - Project Description (Popis vědecké části projektu)

V Ostravě dne _____

V Brně dne _____

prof. Ing. Igor Ivan, Ph.D.
rektor
za příjemce

Ing. Zdeněk Krejza, Ph.D.
předseda správní rady
za dalšího účastníka

RNDr. Theodor Staněk, Ph.D.
místopředseda správní rady
za dalšího účastníka

Part A - Basic Info

Project proposal for a public tender in research, experimental development and innovation to support basic research grant projects for Standard Projects 2026 (hereinafter referred to as the project)

Registration No. 26-23299S
Starting Date 2026/01/01 **Duration (years)** 3
Project Title in English Mechano-chemical carbonation for cementing CO₂ in concrete
Main Panel P107 - Inorganic materials science and engineering
Field of research Cements and concretes
Keywords in English Carbon_dioxide; Solid_wastes; Low-carbon_concrete; Mechanochemical_carbonation; Carbon_capture_and_sequestration;

Applicant and Organisation

Name and Surname	[REDACTED]	Date of Birth	[REDACTED]
E-mail	[REDACTED]	Phone Number	[REDACTED]
Organisation	VSB-Technical University of Ostrava, Faculty of Materials Science and Technology		
Address	17. listopadu 2172/15,	CRN	61989100

Co-Applicant and Co-Organisation - 1

Name and Surname	[REDACTED]		
E-mail	[REDACTED]		
Organisation	Research Institute for Building Materials		
Address	Hněvkovského 65,	CRN	26232511

Abstract in English Accelerated carbonation is an emerging and cutting-edge direction in engineering materials science. However, this approach is limited by the knowledge gap of multi-factor coupling carbonation mechanisms, restricted carbonation efficiency and reduced re-hydration activity. The project aims to design a novel gas-liquid-solid carbonation reaction system with assistance of wet grinding force, thus establishing a novel mechanochemically accelerated carbonation method. By injecting CO₂ during wet grinding, mechanical force continuously strips the carbonate layer on particle surfaces to notably improve carbonation efficiency. The fundamental roles of mechanochemically carbonated wastes will be investigated to understand their physicochemical transformations and their influence on cementitious systems. The project outputs will contribute to understanding the mechanisms of mechanochemically accelerated carbonation, offer new ideas of carbon neutrality approach for the sustainable engineering materials.

Project Aims in English This project aims to design a novel gas-liquid-solid carbonation reaction system and establish a novel mechanochemical carbonation method. Most importantly, the mechanisms of mechanochemical carbonation and its fundamental role in the resulting carbon sequestration concrete will be revealed.

OECD Classification

Materials engineering

Priorities enrollment

It may be suspected, that the results will contribute to the knowledge in following field(s) of National priorities of oriented research, experimental development and innovations:
 Innovation and sustainability of the classical materials

Part B – Total Funds

All amounts shall be filled out in CZK.

Total grant project eligible costs from all funding sources

	Year 1	Year 2	Year 3	Total
Total Provider project subsidy	2,885 K	2,903 K	2,837 K	8,625 K
Support from other public sources (domestic and foreign)	0 K	0 K	0 K	0 K
Support from non-public sources (own resources, private subsidies)	0 K	0 K	0 K	0 K
Eligible costs from all funding sources	2,885 K	2,903 K	2,837 K	8,625 K
Proportion of Provider support	100.00 %			

Project subsidy distribution (exchange rate: 25.19 CZK/EUR) Other project sources distribution

	Year 1	Year 2	Year 3	Total
Material costs	1,240 K 49,226 €	1,258 K 49,940 €	1,192 K 47,320 €	3,690 K 146,487 €
Personnel costs	1,645 K 65,304 €	1,645 K 65,304 €	1,645 K 65,304 €	4,935 K 195,911 €
Investment costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Total	2,885 K 114,530 €	2,903 K 115,244 €	2,837 K 112,624 €	8,625 K 342,398 €

	Year 1	Year 2	Year 3	Total
Material costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Personnel costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Investment costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Total	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €

Organisation - Part A2 - Identification Data

ORCID	0000-0002-5332-7862	Year of receiving Ph.D.	2017
SCOPUS ID	56923922100	Researcher ID	AAY-3338-2021
Primary institution	People's Republic of China, Hubei University of Technology		
URL of gender plan	https://www.vsb.cz/export/sites/vsb/cs/.content/galerie-souboru/GEP_VSB-TUO_ENG.pdf		

Organisation - Part B - Funds in Detail

Name and Surname Assoc. Prof. Jin Yang PhD.

Organisation VŠB-Technical University of Ostrava, Faculty of Materials Science and Technology

All amounts shall be filled out in CZK.

Total grant project eligible costs from all funding sources

	Year 1	Year 2	Year 3	Total
Total Provider project subsidy	1,818 K	1,674 K	1,602 K	5,094 K
Support from other public sources (domestic and foreign)	0 K	0 K	0 K	0 K
Support from non-public sources (own resources, private subsidies)	0 K	0 K	0 K	0 K
Eligible costs from all funding sources	1,818 K	1,674 K	1,602 K	5,094 K
Proportion of Provider support	100.00 %			

Project subsidy distribution (exchange rate: 25.19 CZK/EUR) Other project sources distribution

	Year 1	Year 2	Year 3	Total
Material costs	983 K 39,023 €	839 K 33,307 €	767 K 30,449 €	2,589 K 102,779 €
Personnel costs	835 K 33,148 €	835 K 33,148 €	835 K 33,148 €	2,505 K 99,444 €
Investment costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Total	1,818 K 72,171 €	1,674 K 66,455 €	1,602 K 63,597 €	5,094 K 202,223 €

	Year 1	Year 2	Year 3	Total
Material costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Personnel costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Investment costs	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €
Total	0 K 0 €	0 K 0 €	0 K 0 €	0 K 0 €

Organisation - Part B - Breakdown of Funds

In this part subsidy from GACR shall be filled out

Subsidy for material costs

	Year 1	Year 2	Year 3	Total
Costs of materials	500 K	400 K	370 K	1,270 K
Travel costs	80 K	60 K	60 K	200 K
Other services costs and non-material costs	100 K	100 K	70 K	270 K
Additional (overhead) costs	303 K	279 K	267 K	849 K
Total	983 K	839 K	767 K	2,589 K

Subsidy for personnel costs (summary)

	Year 1	Year 2	Year 3	Total
Professional co-workers' salaries	566 K	566 K	566 K	1,698 K
Other workers' salaries	54 K	54 K	54 K	162 K
DPP/DPČ remunerations	0 K	0 K	0 K	0 K
Social and health insurance and SF	215 K	215 K	215 K	645 K
Total	835 K	835 K	835 K	2,505 K

Subsidy for investment costs

		Year 1		Year 2		Year 3	
Investment	Purchase cost	El.Cost/Dep.	Use(%)	El.Cost/Dep.	Use(%)	El.Cost/Dep.	Use(%)
Total subsidy for investments		0 K		0 K		0 K	

Breakdown of labor costs and DPP/DPČ remunerations covered from subsidy for all years of solution

Cat.	Name	Job description / description of activities	FTE/year 1 Subsidy	FTE/year 2 Subsidy	FTE/year 3 Subsidy
senior	Jin Yang	Project leader - define research goals, coordinate research activities, interim reports; data processing; present the research results to the scientific community	0.400 307 K	0.400 307 K	0.400 307 K
student	Senye Liu	Material and sample preparation and the mechanochemically accelerated carbonation experiments.	0.300 144 K	0.300 144 K	0.300 144 K
student	Michael Pánek	Microstructure and performance evaluation of low-carbon concrete.	0.200 115 K	0.200 115 K	0.200 115 K
senior	Other co-workers (technical staff)	Purchase of raw materials, routine material analyses, preparation of samples	0.100 54 K	0.100 54 K	0.100 54 K

Organisation - Part B - Funds in Detail

Specification and justification of costs for the whole period of solution**Costs of materials**

Costs of materials are mainly used for raw materials and freight costs related to experimental research. Based on the research tasks and experimental content of the project, the main raw materials include Portland cement (3 t), gravel (4/8 mm, 4 t), sand (0/4 mm, 4 t), industrial by-products (steel slag, coal fly ash, granulated blast furnace slag, totally 10 t), grinding media (agate grinding balls, 40 kg), grinding aid (polycarboxylate superplasticizer, 200 kg), CO₂ gas (4000 L), N₂ gas (for the CO₂ concentration controlling, 2400 L), chemical functional additives (including triethanolamine, 100 L; glycine, 50 kg; ethylenediaminetetraacetic acid, 40 kg; etc.), chemical reagents (for example, anhydrous ethanol, 300 kg; sodium hydroxide, 100 kg; sodium silicate, 100 kg; ammonia solution, 300 kg; magnesium chloride, 200 kg; nano calcium carbonate, 100 kg; nano silicon dioxide, 100 kg). The amount of material is approximate.

Travel costs

This is mainly used for expenses related to international academic conferences, accommodation, transportation costs, and international cooperation and exchanges in foreign countries, for example Germany, UK, Japan, China, etc. For international conferences, twice a year, with two participants each time, for a duration of 3 days per attendance. It also includes domestic travel costs in Czech Republic for the applicant and the team to travel to Prague, Brno, and other locations for academic meetings and experimental.

Other services costs and non-material costs

Based on the research tasks and experimental content of the project, this proposal involves a number of tests and characterizations of the physicochemical performances and microstructures, which need outside testing service, including Solid-state Nuclear Magnetic Resonance (32 samples), X-ray Fluorescence analysis (15 samples), pore structure analysis (30 samples), etc. At the same time, some results would be published as open-access articles (plan for 2), and article publishing charges are estimated according to the publication plan in the proposal.

Personnel costs

Personnel costs mainly include professional workers' salaries, social and health insurance and social fund. The work carried out at the VSB - Technical University of Ostrava will involve assoc. prof. Jin Yang, Ph.D. (main investigator), students MSc. Senye Liu and Ing. Michael Panek and one co-worker Ing. David Dvořák. Salaries are defined in accordance with internal regulations.

Investment costs

Investments will not be acquired.

Organisation - Part D2 - Bibliography

Full bibliographic data in the last 10 years regarding the most important results of scientific and research activity as defined in the Methodology for Evaluating the Results of Research and Development

Result	Result type code	Database	Citations	Impact factor	Output benefits and contribution towards the publication
J. Yang, J. Huang, Y. Su, et al. Eco-friendly treatment of low-calcium coal fly ash for high pozzolanic reactivity: A step towards waste utilization in sustainable building material. Journal of Cleaner Production, 2019, 238, 117962. 1 ESI highly cited paper	Jimp	WOS	180	9.800	The applicant is the first author of this paper, and contributes to the Writing – review & editing, Validation, Methodology, Investigation, Data curation and Conceptualization.
X. He, Z. Zheng, J. Yang, et al. Feasibility of incorporating autoclaved aerated concrete waste for cement replacement in sustainable building materials. Journal of Cleaner Production, 2020, 250, 119455. 2 ESI highly cited paper	Jimp	WOS	151	9.800	The applicant is the corresponding author of this paper, and contributes to the review & editing, Methodology, Investigation and Conceptualization.
J. Yang, H. Hu, X. He, et al. Effect of steam curing on compressive strength and microstructure of high volume ultrafine fly ash cement mortar, Construction and Building Materials 2021, 266, 120894. 3 ESI highly cited paper	Jimp	WOS	102	7.400	The applicant is the first author of this paper, and contributes to the Writing – review & editing, Methodology, Investigation and Conceptualization.
J. Yang, J. Zeng, X. He, et al. Sustainable clinker-free solid waste binder produced from wet-ground granulated blast-furnace slag, phosphogypsum and carbide slag, Construction and Building Materials 2022, 330, 127218. 4 ESI highly cited paper	Jimp	WOS	112	7.400	The applicant is the first author of this paper, and contributes to the Writing – review & editing, Methodology, Investigation and Conceptualization.
J. Yang, F. Wang, Z. Liu, et al. Early-state water migration characteristics of superabsorbent polymers in cement pastes, Cement and Concrete Research 2019, 118, 25-37. 5 Research	Jimp	WOS	90	10.900	The applicant is the first author of this paper, and contributes to the Writing – review & editing, Methodology, Investigation and Conceptualization.

Total number of citations, including autocitations, and H-index (according to Web of Science)

Total number of citations, of all of the scientific work according to WOS 3,453

Used methodology and total number of citations "by used Methodology"

H-index according to Web of Science 33.00

Organisation - Part D2 - Other achieved results

Number of educated and currently led postdoctorands, doctorands and students

Ph.D. students: 1
Master's degree students: 25

Invited lectures

- 1) 2022.8, The 2nd 'Science Bridge' International Workshop on High performance Green Construction Materials and Technology, Kunming, Invited lecture, Title: Regulation and mechanism of multiple water release for SAP internal curing materials based on rigid skeleton structure
- 2) 2024.5, 2nd China Academic and Technical Conference on Solid Waste Utilization and Low-carbon Civil Engineering Materials, Jinan, Invited lecture, Title: Ultra-finement of Solid Waste to the Nanometer and Micron Scale and Its Early-strength Effect as Crystal Nucleation Seed
- 3) 2023.12, Innovation Forum of Geology and Engineering Materials, Wuhan, Keynote lecture. Title: Ultra-finement of Solid Waste and Its Application in Green Ultra-high Performance Concrete
- 4) 2023.5, Academic and Technical Conference on Solid Waste Utilization and Low-carbon Civil Engineering Materials, Zhengzhou, Invited lecture, Title: Research on the Disposal and Recycling of Waste Aerated Concrete
- 5) 2021.10, 4th China Academic and Technical Exchange Conference on Solid Waste Treatment and Ecological Materials, Wuhan, Invited lecture, Title: Research on the Recycling and Utilization of Lightweight and Porous Construction Waste in Cement-based Materials

Significant awards

- 1) Member of the Technical Committee of RILEM TC 294-MPA
- 2) Member of the Technical Committee of RILEM TC 309-MCP
- 3) Member of the Technical Committee of RILEM TC-UMW
- 4) Member of the Academic Committee of The 5th International Conference on 3D Printing Concrete Materials and Structures (3DPCMS 2025)
- 5) Member of the Academic Committee of International Conference on Applied Mechanics, Materials Physics, and Engineering Structures (MMPES 2023)
- 6) Young Editorial Board Member of International Journal of Minerals, Metallurgy and Materials (SCI)
- 7) Editorial Board Member of Fluid Dynamics & Materials Processing (ESCI, EI)
- 8) Young Editorial Board Member of Advanced Engineering Sciences (EI)
- 9) Editorial Board Member of Experimental Results (Cambridge University Press)
- 10) Guest editor-in-chief of Materials (SCI)
- 11) Co-guest editor of Frontiers in Chemistry (SCI)
- 12) Co-guest editor of Coatings (SCI)
- 13) Guest editor-in-chief of Journal of Renewable Materials (EI)

Significant projects

- 1) Funding type: General Project of the National Natural Science Foundation (NSFC of China); Provider: NSFC Committee; 52172017; Mechanism for Improving the Aging Effect of Crack Self-healing of Nanocomposite Hydrogels Based on Barrier Functional Layers and Built-in Reactive Sources; 2022.1-2025.12; 1840 kCZK; PI
- 2) Funding type: Youth Project of the National Natural Science Foundation (NSFC of China); Provider: NSFC Committee; 51902095; Study on the Multiple Water Release Regulation and Action Mechanism of SAP Internal Curing Materials Based on Rigid Skeleton Structure; 2020.1-2022.12; 793 kCZK; PI
- 3) Funding type: Sub-project of the National Key Research and Development Program; Provider: Ministry of Science and Technology of China; 2019YFC1907103-01; Design and Performance Optimization of Solid Waste Cementitious Material System for Underground Cemented Backfill and 3D Printing; 2020.1-2022.12; 5921 kCZK; PI
- 4) Funding type: Major Special Project of Scientific and Technological Innovation in Hubei Province; Provider: Hubei Provincial Department of Science and Technology; 2019ACA146-01, Technologies of Fine Aggregate Paste-Aggregate Stripping, Shaping and Micron and Nanometer Ultrafining of Micropowder; 2019.1-2020.12; 2538 kCZK; PI
- 5) Funding type: General Project of Hubei Provincial Natural Science Foundation; Provider: Hubei Provincial Department of Science and Technology; 2019CFB170; Study on the Water Transport Behavior of SAP Polymer in Concrete and the Strengthening/Deterioration Mechanism of Its Interface Zone; 2019.1-2020.12; 158 kCZK; PI

Scientific activity

The applicant has previously conducted extensive research on wet grinding activation disposal of solid wastes. He developed a liquid-solid two-phase ultra-fine grinding system and established a multi-scale mechanism and new activation method for solid waste based on "micro-nano sizing of solid waste, lattice distortion, and ionic intervention". According to WoS publication analysis, the applicant ranks 4th in the field of wet-grinding solid wastes (topics: "wet grinding" AND "solid wastes"). It was found that wet grinding significantly promotes the early release of alkaline ions from solid waste, achieves the ultra-fine pulverization, and increases surface reaction sites, thus enhancing the pozzolanic reaction. Based on this, we proposed an innovative approach of "coupling wet grinding force with CO₂ mineralization" (we call it mechanochemical carbonation) in this proposal and reveal its working mechanisms.

Participation in evaluation panels

No.

Organisation - Part E – Related Projects

Ongoing projects (including the foreign ones)

Provider	National Natural Science Foundation of China		
Program Name	General Project	Registration No.	52172017
Role in The Project	Investigator	Panel (GACR only)	
Full project name	Mechanism for Improving the Aging Effect of Crack Self-healing of Nanocomposite Hydrogels Based on Barrier Functional Layers and Built-in Reactive Sources		
OECD Classification	Materials engineering		
Subsidy for Beneficiary	1,840 K	FTE	0.50
Starting Date	1.1.2022	End Date	31.12.2025
Beneficiary Name			
Relation to Project Proposal	This project focuses on the regulation of the self-healing process and the improvement of the timeliness of superabsorbent polymer (SAP) hydrogels. It proposes a new design concept for nano-composite hydrogels that combine both physical swelling and endogenous reactions. There is no relationship with this proposal.		

Proposed projects (including the foreign ones)

There are no projects proposed at this time.

Finished projects

Provider	National Natural Science Foundation of China		
Program Name	Youth Project	Registration No.	51902095
Role in The Project	Investigator	Panel (GACR only)	
Full project name	Study on the Multiple Water Release Regulation and Action Mechanism of SAP Internal Curing Materials Based on Rigid Skeleton Structure		
OECD Classification	Materials engineering		
Subsidy for Beneficiary	793 K	FTE	0.25
Starting Date	1.1.2020	End Date	31.12.2022
Beneficiary Name			
Relation to Project Proposal	In this project, a novel PM/SAP composite with rigid skeleton structure (PM) was designed. The chemically controlled water release of SAP and the graded desorption of porous PM framework was used to multiply control the desorption behavior of PM/SAP composite and improving the internal curing efficiency. There is no relationship with this proposal.		
The Final Evaluation	accomplished (U/S/B)		
Provider	Ministry of Science and Technology of China		
Program Name	Sub-project of the National Key Research and Development Program	Registration No.	2019YFC1907103-01
Role in The Project	Investigator	Panel (GACR only)	
Full project name	Design and Performance Optimization of Solid Waste Cementitious Material System for Underground Cemented Backfill and 3D Printing		
OECD Classification	Materials engineering		
Subsidy for Beneficiary	5,921 K	FTE	0.25
Starting Date	1.1.2020	End Date	31.12.2022
Beneficiary Name			
Relation to Project Proposal	In this project, three types of industrial solid wastes, wet ground granulated blast-furnace slag (WGGBS), phosphogypsum (PG) and carbide slag (CS), were designed as clinker-free, high-performance ternary binders for applications such as construction and underground filling and 3D printing. There is no relationship with this proposal.		
The Final Evaluation	accomplished (U/S/B)		
Provider	Hubei Provincial Department of Science and Technology		
Program Name	Major Special Project of Scientific and Technological Innovation in Hubei Province	Registration No.	2019ACA146-01
Role in The Project	Investigator	Panel (GACR only)	
Full project name	Technologies of Fine Aggregate Paste-Aggregate Stripping, Shaping and Micron and Nanometer Ultrafining of Micropowder		
OECD Classification	Materials engineering		
Subsidy for Beneficiary	2,538 K	FTE	0.25
Starting Date	1.1.2019	End Date	31.12.2020
Beneficiary Name			
Relation to Project Proposal	In this project, wet grinding method was used to improve the fineness of recycled concrete fines. The physical and chemical activation mechanisms of recycled concrete fines were discussed. The developed wet grinding method provides inspiration for the mechanochemical carbonation in this proposal. But there is no relationship with the rapid carbonation in this proposal.		
The Final Evaluation	accomplished (U/S/B)		

Provider	Hubei Provincial Department of Science and Technology		
Program Name	General Project of Hubei Provincial Natural Science Foundation	Registration No.	2019CFB170
Role in The Project	Investigator	Panel (GACR only)	
Full project name	Study on the Water Transport Behavior of SAP Polymer in Concrete and the Strengthening /Deterioration Mechanism of Its Interface Zone		
OECD Classification	Materials engineering		
Subsidy for Beneficiary	158 K	FTE	0.25
Starting Date	1.1.2019	End Date	31.12.2020
Beneficiary Name			
Relation to Project Proposal	In this project, the early water exchange between superabsorbent polymer and cement pastes is investigated, the desorption mechanisms driven by osmotic pressure and humidity gradient, as well as the strengthening and deterioration mechanism of its interfacial zone were revealed. There is no relationship with this proposal.		
The Final Evaluation	accomplished (U/S/B)		

Co-Organisation - Part A2 - Identification Data

ORCID	0000-0002-9185-2078	Year of receiving Ph.D.	
SCOPUS ID	55916954900	Researcher ID	H-5115-2018
Primary institution	Czech republic, Research Institute for Building Materials		
URL of gender plan	https://acrobat.adobe.com/id/urn:aaid:sc:eu:7d70cd00-a3d4-4a31-b2d2-5e82d875acff		

Co-Organisation - Part B - Funds in Detail

Name and Surname Ing. Martina Drdlová
Organisation Research Institute for Building Materials
 All amounts shall be filled out in CZK.

Total grant project eligible costs from all funding sources

	Year 1	Year 2	Year 3	Total
Total Provider project subsidy	1,067 K	1,229 K	1,235 K	3,531 K
Support from other public sources (domestic and foreign)	0 K	0 K	0 K	0 K
Support from non-public sources (own resources, private subsidies)	0 K	0 K	0 K	0 K
Eligible costs from all funding sources	1,067 K	1,229 K	1,235 K	3,531 K
Proportion of Provider support	100.00 %			

Project subsidy distribution (exchange rate: 25.19 CZK/EUR) Other project sources distribution

	Year 1	Year 2	Year 3	Total
Material costs	257 K	419 K	425 K	1,101 K
Personnel costs	10,202 €	16,634 €	16,872 €	43,708 €
Personnel costs	810 K	810 K	810 K	2,430 K
Personnel costs	32,156 €	32,156 €	32,156 €	96,467 €
Investment costs	0 K	0 K	0 K	0 K
Investment costs	0 €	0 €	0 €	0 €
Total	1,067 K	1,229 K	1,235 K	3,531 K
Total	42,358 €	48,789 €	49,027 €	140,175 €

	Year 1	Year 2	Year 3	Total
Material costs	0 K	0 K	0 K	0 K
Material costs	0 €	0 €	0 €	0 €
Personnel costs	0 K	0 K	0 K	0 K
Personnel costs	0 €	0 €	0 €	0 €
Investment costs	0 K	0 K	0 K	0 K
Investment costs	0 €	0 €	0 €	0 €
Total	0 K	0 K	0 K	0 K
Total	0 €	0 €	0 €	0 €

Co-Organisation - Part B - Breakdown of Funds

In this part subsidy from GACR shall be filled out

Subsidy for material costs

	Year 1	Year 2	Year 3	Total
Costs of materials	50 K	50 K	50 K	150 K
Travel costs	30 K	50 K	50 K	130 K
Other services costs and non-material costs	0 K	115 K	120 K	235 K
Additional (overhead) costs	177 K	204 K	205 K	586 K
Total	257 K	419 K	425 K	1,101 K

Subsidy for personnel costs (summary)

	Year 1	Year 2	Year 3	Total
Professional co-workers' salaries	425 K	425 K	425 K	1,275 K
Other workers' salaries	180 K	180 K	180 K	540 K
DPP/DPČ remunerations	0 K	0 K	0 K	0 K
Social and health insurance and SF	205 K	205 K	205 K	615 K
Total	810 K	810 K	810 K	2,430 K

Subsidy for investment costs

		Year 1		Year 2		Year 3	
Investment	Purchase cost	El.Cost/Dep.	Use(%)	El.Cost/Dep.	Use(%)	El.Cost/Dep.	Use(%)
Total subsidy for investments		0 K		0 K		0 K	

Breakdown of labor costs and DPP/DPČ remunerations covered from subsidy for all years of solution

Cat.	Name		FTE/year 1	FTE/year 2	FTE/year 3
	Job description / description of activities		Subsidy	Subsidy	Subsidy
senior	Martina Drdlová Project co-investigator. Project management of the research activities at home facility. Design of carbon sequestration concrete, multi-scale characterization. Publication and dissemination activities.		0.250 180 K	0.250 180 K	0.250 180 K
postdoc	Martin Nguyen Accelerated carbonation of various materials and wastes, XRD analyses with quantitative calculations, carbonation regimes, and processes, evaluation of data, participation on publications		0.250 158 K	0.250 158 K	0.250 158 K
senior	Petr Bibora Experimental work in the carbonation of cement matrix and secondary waste materials. Measurement of the level of carbonation via securing the element analyses and material characterization. Evaluation of data.		0.150 87 K	0.150 87 K	0.150 87 K
senior	Other co-workers (technical staff) Purchase of raw materials, routine material analyses, preparation of samples.		0.350 180 K	0.350 180 K	0.350 180 K

Co-Organisation - Part B - Funds in Detail

Specification and justification of costs for the whole period of solution

Costs of materials

The Research Institute for Building Materials uses raw inorganic materials such as Portland cement of various types and other supplementary cementitious materials (SCMs), sand, coarse aggregates, and various additives on a daily basis. Nevertheless, some of these materials have limited shelf lives and thus need to be bought just in time. Additionally, cement undergoes hydration with air moisture once opened. The major cost issues may arise from certain specialized materials, such as chemical functional additives (including triethanolamine, 50 L; glycine, 25 kg; ethylenediaminetetraacetic acid, 20 kg; etc.), chemical reagents (e.g., anhydrous ethanol, 100 kg; sodium hydroxide, 50 kg; sodium silicate, 50 kg; ammonia solution, 200 kg; magnesium chloride, 100 kg; nano calcium carbonate, 50 kg; nano silicon dioxide, 50 kg), as well as CO₂ and N₂ gases (4,000 L and 2,400 L, respectively). The amounts of materials are approximate.

Travel costs

Travel expenses cover accommodation, transportation, and subsistence costs for research team members attending conferences where project results will be presented, with one participant each time, for a duration of 3 days per attendance. During the project period, the following active conference participations are planned: ICCO, ISCC or RILEM series.

Costs also address the need for research team members on both sides to regularly meet each other on the route Ostrava-Brno. These costs include train tickets and/or fuel expenditures, as well as accommodation. Meetings are planned to take place at least twice a year.

Other services costs and non-material costs

Costs for other services include conference fees for two international conferences (25,000 CZK per year), one in 2027 and the other in 2028.

As part of an external service, proofreading and graphical editing of manuscripts in English are planned (2027: 20,000 CZK; 2028: 25,000 CZK). Additionally, open-access publication fees are included (70,000 CZK in both 2027 and 2028).

The costs of analytical instrument analyses for material structure determination are covered under overhead expenses.

Personnel costs

The personnel costs for the project are determined in accordance with VÚSH's internal wage regulations and correspond to standard wages for the time and location of the project.

The personnel costs will cover the salaries of the team members, including:

Ing. Martina Drdlová (0.25 FTE) with a salary of 180K CZK per year. She will manage the project at VÚSH, a.s. as a co-investigator, ensuring all deadlines are met according to the project schedule. She will also be responsible for evaluating results. Design of carbon sequestration concrete, multi-scale characterization. Publication and dissemination activities.

Ing. Martin Nguyen, Ph.D. (0.25 FTE) with a salary of 158K CZK per year. He will focus on accelerated carbonation curing of various materials, solid-state synthesis, and the utilization of waste materials in the construction industry. His expertise includes XRD analysis with quantitative calculations, carbonation regimes, and processes. He will also be responsible for evaluating partial results and contributing to publications.

Ing. Petr Bibora (0.15 FTE) with a salary of 87K CZK per year. He will conduct most of the experiments related to accelerated carbonation of cement composites and waste materials, evaluate partial results, and contribute to publication writing.

Technical staff (0.35 FTE) with a salary of 180K CZK per year. These team members will carry out routine analyses, prepare moulds and samples, and conduct measurements such as flexural and tensile strengths, porosity, etc. Given the critical role of these tasks in the project, this position has been assigned the highest FTE allocation.

The costs of social insurance, health insurance, and social funds are calculated at 34.8% of the salary based on Czech law, which amounts to 633K CZK per the whole project realization.

Investment costs

Investments will not be acquired.

Co-Organisation - Part D2 - Bibliography

Full bibliographic data in the last 10 years regarding the most important results of scientific and research activity as defined in the Methodology for Evaluating the Results of Research and Development

Result	Result type code	Database	Citations	Impact factor
1 Drdlova, M, Buchar, J, Ridky, R, Kratky, J: Blast resistance characteristics of concrete with different types of fibre reinforcement, Structural Concrete, Vol. 16, Is. 4. 2015	Jimp	WOS	29	3.000
2 Drdlova, M, Frank, M, Buchar, J, Ridky, R, Soukal, F: Effect of Nanoparticle Modification on Static and Dynamic Behaviour of Foam Based Blast Energy Absorbers, Cellular Polymers, Vol. 35, Is. 3. 2016	Jimp	WOS	7	1.300
3 Soukal, R et al. The Effects of Silica Fume and Superplasticizer Type on the Properties and Microstructure of Reactive Powder Concrete, Materials, Vol. 16, Is. 20. 2023	Jimp	WOS	8	3.100
4 Drdlova, M., Popovic, M, Koutny, O: Blast resistance of hybrid fibre reinforced concrete containing polyvinylalcohol, polypropylene and steel fibres with various shape parameters, European physical journal, Vol. 227, Is. 1-2, 2018	Jimp	WOS	5	2.600
5 Drdlova, M, Frank, M, Prachar, V: Effect of filler on the mechanical and dynamic properties of impact energy-absorbing materials, Polymers and polymer composites, Vol. 24, Is. 1. 2016	Jimp	WOS	7	2.100

Total number of citations, including autocitations, and H-index (according to Web of Science)

Total number of citations, of all of the scientific work according to	WOS 114
Used methodology and total number of citations "by used Methodology"	Scopus
H-index according to Web of Science	6.00

Co-Organisation - Part D2 - Other achieved results

Number of educated and currently led postdoctorands, doctorands and students

Management of professional internships of students at VÚSH workplaces.

Invited lectures

N/A

Significant awards

N/A

Significant projects

1) TJ01000257 – Measurement of materials at high strain rates using Split Hopkinson Pressure Bar technique (TA CR, 2018–2019, funding: 1,658 thousand CZK). PI. Focused on the characterization of materials under high strain rates using the Split Hopkinson Pressure Bar technique. Completed with an "excellent results" rating.

2) VI20192022129 – Restraint systems designed to stop trucks (MV CR, 2019–2022, funding: 10,482 thousand CZK). Co-investigator. Conducted dynamic testing of materials and barrier system components, including concrete, polymer coatings, and full-scale crash tests.

3) FW01010355 – Development of the automated technology for the production of high-tech composite pressure vessels (TA CR, 2020–2022, funding: 2,544 thousand CZK). Co-investigator. Focused on the development of a high-performance FRP composite with enhanced load-bearing capacity and impact resistance.

4) GA13-22945S – Research on advanced constructions for impact energy absorption and their behaviour at high strain rates (GA CR, 2013–2015, funding: 999 thousand CZK). Team member. Investigated high strain rate properties of syntactic foams, including nanoparticle-modified systems.

5) CAMPT – Centre of advanced materials and technologies for protection and safety enhancement (MV CR, 2014–2020, funding: 198 000 thousand CZK). Principle technical investigator (VUSH part). Research and development in blast energy absorbers, blast-resistant concrete, and ballistic laminates. Completed with an "excellent results" rating.

Scientific activity

Ing. Martina Drdlová (WOS: 30 publications, 113 citations, h-index 6) is the head of the Composite Materials Department. She has 15 years of experience in material research and the development of high-performance and sustainable composite materials. Over the past decade, her research has focused on the behaviour of materials under high strain rates.

As part of her work, she and her team developed a new device for measuring materials' high strain rate characteristics based on the Split Hopkinson Pressure Bar (SHPB) principle. By leveraging innovative measurement techniques, M. Drdlová has significantly advanced the understanding of fiber-cement materials' behaviour under high-speed tensile stresses, expanding the frontiers of knowledge in this critical field. Her expertise in material behaviour under high strain rates is particularly relevant to the project's mechanochemical approach.

In the field of sustainability, her research focuses on technologies for treating secondary raw materials using physico-mechanical and chemical methods, including CO₂ treatment and their incorporation into building materials. She has extensive experience in designing materials using by-products and secondary raw materials. Her expertise in this area makes her a valuable team member for the proposed project, which also addresses the sustainable development of the concrete industry.

Participation in evaluation panels

Member of the panel for selection of projects for the laboratories ELSA HopLab and Reaction Wall lab (Joint Research Centre, Italy,) and Expert work for the European Commission – EIC Accelerator project evaluator. (contract No. CTEX2016D272027-113 and CT-EX2016D272027-112)

Co-Organisation - Part E – Related Projects

Ongoing projects (including the foreign ones)

Provider Czech Science Foundation

Program Name Standard grant projects **Registration No.** 25-15917S

Role in The Project Co-investigator **Panel (GACR only)**

Full project name Strengthening fabric-matrix interphase adhesion and enhancing high strain rate characteristics of FRP composites by surface plasma treatment of fibres

OECD Classification Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)

Subsidy for Beneficiary 4,006 K **FTE** 0.25

Starting Date 1.3.2025 **End Date** 29.2.2028

Beneficiary Name Masarykova Univerzita

Relation to Project Proposal The aim of the project is to clarify the relationships and interconnections between fibre surface functionalization by plasma, the interfacial properties of the fibre-matrix interface and the final properties of fibre-reinforced composites under high strain rate loading. There is no thematic overlap with the proposed project.

Provider Technology Agency of the Czech Republic

Program Name CK - Program na podporu aplikovaného výzkumu, experimentálního vývoje a inovací v oblasti dopravy - DOPRAVA **Registration No.** CK04000107

Role in The Project Co-investigator **Panel (GACR only)**

Full project name Research and Development of Advanced Composite Cylinders for Alternative Fuels

OECD Classification Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)

Subsidy for Beneficiary 336 K **FTE** 0.20

Starting Date 1.1.2023 **End Date** 31.12.2025

Beneficiary Name HPC Research, Výzkumný ústav stavebních hmot, a.s., Ústav teoretické a aplikované mechaniky AV ČR, v.v.i.

Relation to Project Proposal The project's main objective is to develop a new type of high-pressure composite vessel for hydrogen storage. The vessel will be based on a specific carbon FRP composite and a liner made of ultra-thin aluminium alloys or plasma-coated foils to ensure a sufficient leak barrier against the diffusion of small hydrogen molecules. The project focuses on the research and development of composites for cylinders produced by filament winding. The material aspect of the project explores the use of secondary-quality carbon fibres in concrete. The relation to the proposed project lies in similar material characterisation and experience with material design utilising secondary materials.

Provider	Technology Agency of the Czech Republic		
Program Name	FW Trend	Registration No.	FW06010145
Role in The Project	Co-investigator	Panel (GACR only)	
Full project name	Advanced Containers for Tank and Artillery Ammunition		
OECD Classification	Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)		
Subsidy for Beneficiary	3,315 K	FTE	0.20
Starting Date	1.1.2023	End Date	31.12.2025
Beneficiary Name	Bogges, spol. s r.o., Výzkumný ústav stavebních hmot, a.s., Vojenský výzkumný ústav, s.p.		
Relation to Project Proposal	The project's R&D focuses on the transport and storage of ammunition. It aims to develop a new type of composite ammunition container for two-piece 125 mm tank ammunition, a transport system for a container for 155 mm modular charges, and a container for 155 mm modular charges with improved durability. There is no thematic overlap with the proposed project.		

Proposed projects (including the foreign ones)

Provider	European Commission		
Program Name	European Defence Fund, EDF-2024-LS-RA-SMERO	Registration No.	101224220
Role in The Project	Co-investigator	Panel (GACR only)	
Full project name	Synergistic effects of hybrid material systems for blast and ballistic protection		
OECD Classification	Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)		
Subsidy for Beneficiary	7,737 K	FTE	0.15
Starting Date	1.1.2026	End Date	31.12.2029
Beneficiary Name	SVSFEM s.r.o., Vojenský výzkumný ústav, s.p., Bogges, spol. s r.o., Univeriteit GENT, Politecnico di Milano, Ústav anorganickej chemie slovenská akadémia ved SK, ONE3D, Ministerul apararii national, Amazemet sp. z o.o., WM Safety srl		
Relation to Project Proposal	The overall aim of the project is to enhance European defence capabilities by creating and improving knowledge, solutions, tools and technologies for blast and ballistic protection. Project will surpass existing solutions through comprehensive and innovative methodologies that incorporate hybridisation across various levels, diverse performance identification capabilities, advanced high-fidelity modelling, design guided by artificial intelligence, unconventional material utilisation, and a commitment to sustainability considerations. There is no thematic overlap with the proposed project.		

Provider Ministry of Industry and Trade

Program Name OP TAK Aplikace Deep Tech **Registration No.** CZ.01.01.01/01/24_063/0006784

Role in The Project Co-investigator **Panel (GACR only)**

Full project name Advanced Optimization of FRP Composite Materials Using Plasma Technologies

OECD Classification Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)

Subsidy for Beneficiary 3,800 K **FTE** 0.20

Starting Date 1.1.2026 **End Date** 30.6.2028

Beneficiary Name Prefa Kompozity a.s.

Relation to Project Proposal The project focuses on the use of advanced deep tech techniques for surface treatment of fibre reinforcement by cold atmospheric plasma to create a new generation of FRP composites for demanding applications in the security industry, construction and transport infrastructure. By integrating plasma technology together with numerical modelling, the project aims to develop materials with high impact toughness and improved ballistic properties. There is no thematic overlap with the proposed project.

Provider Technology Agency of the Czech Republic

Program Name Theta 2 **Registration No.** TS02030075

Role in The Project Co-investigator **Panel (GACR only)**

Full project name New methods for energy storage in building structures

OECD Classification Energy and fuels

Subsidy for Beneficiary 5,281 K **FTE** 0.30

Starting Date 1.7.2025 **End Date** 30.6.2029

Beneficiary Name Brno University of Technology

Relation to Project Proposal The project focuses on developing innovative solutions for storing and utilizing energy within the built environment. This includes materials that can store energy sustainably, potentially integrating advanced materials or smart concrete capable of managing thermal and electrical energy. The goal is to form energy-storage concrete by incorporating (nano)carbon materials and/or utilizing the heat capacity of various crystalline and amorphous inorganic compounds (e. g., sand, recycled aggregates) for a Thermal Energy Storage Cell. There is no thematic overlap with the proposed project.

Finished projects

Provider	Technology Agency of the Czech Republic		
Program Name	TJ - Program na podporu aplikovaného výzkumu ZÉTA	Registration No.	TJ01000257
Role in The Project	Investigator	Panel (GACR only)	
Full project name	Measurement of Material Properties at High Strain Rates Using Split Hopkinson Pressure Bar Method		
OECD Classification	Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)		
Subsidy for Beneficiary	1,658 K	FTE	0.30
Starting Date	1.1.2018	End Date	31.12.2019
Beneficiary Name	Výzkumný ústav stavebních hmot, a.s., SVSFEM s.r.o.		
Relation to Project Proposal	The aim of the project was to develop a new device for measuring the high strain rate characteristics of materials based on the Split Hopkinson Pressure Bar (SHPB) principle. The new measurement principle is based on the parallelization of the input and output pulses in compression tests of material samples on the same device. The device was designed to measure the properties of materials subjected to dynamic loads, such as vehicle crashes, ballistic impacts, and drop tests. The project utilized various material testing methodologies, which will be applied in a similar fashion in the proposed project.		
The Final Evaluation	excellent (V/E/A)		
Provider	Technology Agency of the Czech Republic		
Program Name	Competence Centre Programme	Registration No.	TE02000162
Role in The Project	Professional colleague	Panel (GACR only)	
Full project name	Centre of Advanced Materials and Technologies for Protection and Safety Enhancement		
OECD Classification	Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)		
Subsidy for Beneficiary	30,740 K	FTE	0.50
Starting Date	1.1.2014	End Date	31.12.2019
Beneficiary Name	VÚSH, a.s., Bogges, spol. s.r.o., STV Group, a.s., SVSFEM s.r.o., Excalibur ARMY spol. s.r.o., Prototypa-ZM, s.r.o., Ústav teoretické a aplikované mechaniky AV ČR, v.v.i., Vojenský výzkumný ústav, s.p., VUT, STV Group a.s.		
Relation to Project Proposal	As part of the project, R&D focused on developing materials for blast and ballistic protection applications. Hybrid, laminated, shaped, and functional materials were designed and incorporated as key elements in protection solutions.		
The Final Evaluation	excellent (V/E/A)		
Provider	Czech Science Foundation		
Program Name	Standard grant projects	Registration No.	GA13-22945S
Role in The Project	Professional colleague	Panel (GACR only)	
Full project name	Research on Advanced Constructions for Impact Energy Absorption and Their Behaviour at High Strain Rates		
OECD Classification	Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)		
Subsidy for Beneficiary	999 K	FTE	0.40
Starting Date	1.1.2013	End Date	31.12.2015
Beneficiary Name	SVS FEM s.r.o., Výzkumný ústav stavebních hmot, a.s., Bogges spol. s r.o.		
Relation to Project Proposal	Research has been performed on the advanced constructions for impact energy absorption at high strain rates. Constructions were designed in the form of sandwich plates with various layer compositions and core materials. There is no relation to the proposed project.		
The Final Evaluation	accomplished (U/S/B)		

Provider	Technology Agency of the Czech Republic		
Program Name	FW Trend	Registration No.	FW01010021
Role in The Project	Professional colleague	Panel (GACR only)	
Full project name	Means for Ballistic Protection Enhancement of Vehicles and Critical Infrastructure		
OECD Classification	Composites (including laminates, reinforced plastics, cermets, combined natural and synthetic fibre fabrics; filled composites)		
Subsidy for Beneficiary	10,800 K	FTE	0.10
Starting Date	1.1.2020	End Date	31.12.2024
Beneficiary Name	Bogges spol. s r.o., Výzkumný ústav stábeních hmot, a.s., Excalibur ARMY spol. s r.o., Prototypa-ZM, s.r.o., Ústav teoretické a aplikované mechaniky AV ČR, v.v.i., Vojenský výzkumný ústav, s.p., Vysoké učení technické v Brně, Fakulta chemická		
Relation to Project Proposal	The presented project focuses on material research and the subsequent development of means for passive ballistic protection of critical infrastructure and vehicles for state security services, such as the Army and the Integrated Rescue System. During the project, several ballistic protection solutions will be developed, incorporating both existing and newly developed advanced materials, such as ultra-high-performance cementitious composites and hybrid high-strength laminates. The project results represent a comprehensive ballistic protection solution from both a material and structural perspective. The successful fulfilment of the project goals will significantly enhance and ensure public security. This ongoing project is not in any way related to the proposed project.		
The Final Evaluation	not yet rated		

Part C2 - Expected Results Estimate

Expected Project Results Estimate

Description of the result types (with emphasis on quality, not quantity), which are expected to be published while carrying out the grant project (articles in international scientific journals, monographs, international compilations etc.). Complete in English.

Expected Project Results

This project will establish a novel mechanochemical carbonation method, broaden the knowledge of carbonation and activation mechanisms, offer new ideas of carbon neutrality approach for the sustainable building materials. Results will be published in D1 and Q1 Jimp journals, more than half of which are D1 journals. One edited academic book will be published.

Attachments

Project proposal has all mandatory attachments.

Resumes (part D1)

Organisation	Filename	Size
organisation	CV_Jin_Yang_(Final).pdf	287kB
Co-organisation - 1	CV_Drdlova.pdf	149kB

Other attachments

Attachment type	Filename	Size
Part C	Project_Description_(Final).pdf	5432kB

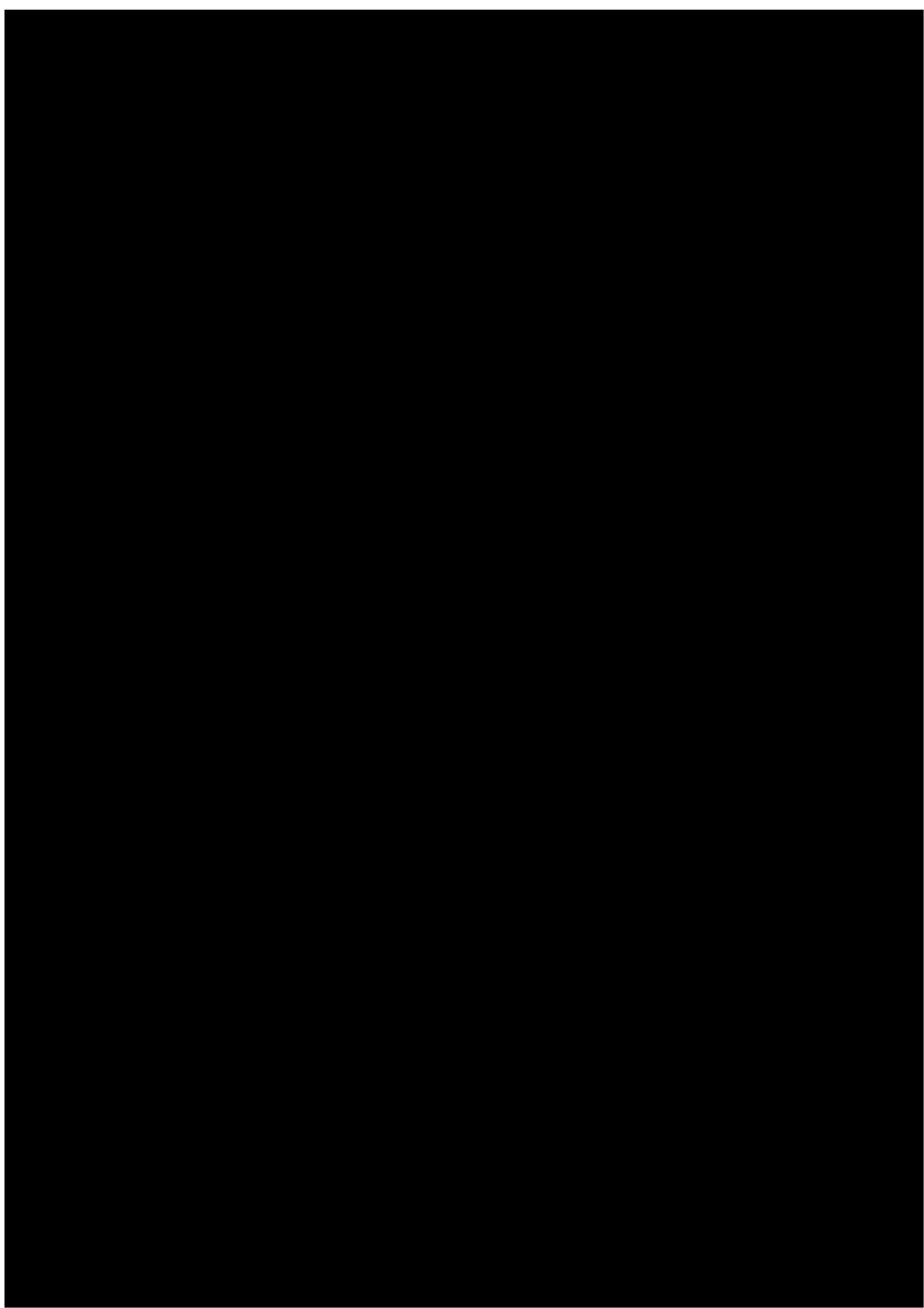
Statement

By submitting a Project Proposal, the Organization warrants that it is familiar with the Tender Document/Rules and agrees to abide by the provisions thereof, including but not limited to the following:

- the Applicant is in employment with the Organization or, exceptionally, such employment shall be established within 4 months of the Grant Project launch, or within the date the Agreement on Grant Funding takes force and effect, or within the date the Decision on Grant Funding is issued;
- once it has executed the Agreement on Grant Funding, the Organization agrees to carry out all the obligations of a Beneficiary as stipulated in Act No. 130/2002, in this Tender Document/Rules, and in the executed Agreement or an effective Decision on Grant Funding;
- the Organization agrees to provide the Investigator with the appropriate administrative support;
- the Organization agrees to provide the Investigator with the appropriate technical and institutional resources, including but not limited to suitable space and/or access to existing equipment during the Project and, where appropriate, after its completion;
- the Organization agrees to provide the Investigator with an ethical and non-discriminatory working environment, to set out an explicit code of ethics compatible with the European Code of Conduct for Research Integrity, and to guarantee a transparent process for dealing with possible breaches of this code; the Organization also confirms that it is not aware of any breach of the code of ethics by the Applicant or the Co-applicant over the last 5 years prior to the year of the publication of the public tender at hand;
- the Organization agrees to abide by, and to require Applicants and Co-applicants, and Investigators and Co-investigators including team members of a Grant Project, to abide by all provisions of the code of ethics. If the Applicant or Co-applicant, Investigator or Co-investigator, or any other member of the project team, is found to have violated the principles of the code of ethics in the course of the Grant Project, or if they are found to have violated the principles of the code of ethics during 5 years immediately prior to the year in which the tender was published, the Provider may disqualify the Project Proposal from the public tender, terminate the Agreement on Grant Funding without notice, revoke the Decision on Grant Funding, or withdraw from the Agreement on Grant Funding;
- the Organization shall procure that following the execution of the Agreement on Grant Funding, the Investigator shall carry out all his or her obligations, including but not limited to being accountable for the professional quality of the project;
- all the information given in the Project Proposal is true, complete and undistorted, and it is identical with the information entered into the Project Proposal through the Web App, that the Project Proposal has been drawn up in compliance with the Tender Document/Rules, that the individuals listed in the Project Proposal meet and shall continue to meet, throughout the entire period during which they are working on the Project, the terms and conditions stipulated in this Tender Document/Rules;
- all Co-organizations, the Applicant, Co-applicants and professional and/or other collaborators nominated in the Project Proposal have been made aware of the material content of the Project Proposal as well as the financial requirements specified therein, and with this Tender Document/Rules;
- before submitting the Project Proposal, the Organization acquired the consent of the aforementioned individuals and/or entities to participating in the Grant Project specified in the Project Proposal;
- the Organization has not accepted, is not accepting and shall not accept funding from another source for a different project with the same or similar subject matter;
- the contents of this Project Proposal are different from any other grant project or programme project in which the same Applicant or Co-applicant is participating, and the proposed scope of work allows the Applicant or Co-applicant to work on all their projects;
- the Organization consents that the data given in the Project Proposal may be used for the Provider's internal needs, and published to the extent laid down by Act No. 130/2002, and this Tender Document/Rules;
- in the event that an Agreement is executed or the Decision on Grant Funding is issued in respect of the Grant Project, the Organization shall abide by the terms and conditions for carrying out Grant Projects as stipulated in the Tender Document/Rules;
- following the execution of the Agreement on Grant Funding or the issuing of the Decision on Grant Funding, the Organization shall secure co-funding of the given Grant Project in accordance with the submitted Project Proposal.

Simultaneously, the organization confirms that all the conditions listed above have been abided and that all the data and information filled out in the project proposal were checked for imperfections.

To the purpose of evaluation, only the last version of the project proposal, being delivered via the data mailbox reserved for GRIS (mailbox-ID: ntq92qs) by the stipulated deadline, shall be accepted to the public tender/call.



The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry, no matter how small, should be recorded to ensure the integrity of the financial statements. This includes not only sales and purchases but also expenses, income, and transfers between accounts.

Next, the document outlines the process of reconciling bank statements with the company's records. This involves comparing the bank's record of transactions with the company's ledger to identify any discrepancies. Common reasons for discrepancies include timing differences, such as deposits in transit or outstanding checks, and errors in recording or omission of transactions.

The document then provides a detailed explanation of the accounting cycle, which consists of eight steps: 1) identifying and recording transactions, 2) journalizing, 3) posting to the ledger, 4) calculating the trial balance, 5) adjusting entries, 6) preparing financial statements, 7) closing the books, and 8) reversing entries. Each step is described in detail, including the necessary journal entries and ledger postings.

Finally, the document discusses the importance of internal controls to prevent fraud and errors. It suggests implementing a system of checks and balances, such as separating duties, requiring approvals for transactions, and conducting regular audits. The document also provides a checklist of key internal control procedures for management to review.



The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry, no matter how small, should be recorded to ensure the integrity of the financial data. This includes not only sales and purchases but also expenses and income. The document provides a detailed list of items that should be tracked, such as inventory levels, accounts payable, and accounts receivable. It also outlines the procedures for recording these transactions, including the use of journals and ledgers. The second part of the document focuses on the reconciliation process. It explains how to compare the company's records with bank statements and other external sources to identify any discrepancies. This process is crucial for detecting errors and preventing fraud. The document provides step-by-step instructions for performing a reconciliation, including how to identify and investigate any differences. The final part of the document discusses the importance of regular audits. It explains that audits are necessary to ensure that the financial records are accurate and that the company is complying with all applicable laws and regulations. The document provides a checklist of items to be audited and outlines the procedures for conducting an audit. It also discusses the role of the auditor and the importance of maintaining a clear audit trail. Overall, the document provides a comprehensive guide to financial record-keeping and reconciliation, and is an essential resource for any business owner or manager.

Czech Science Foundation

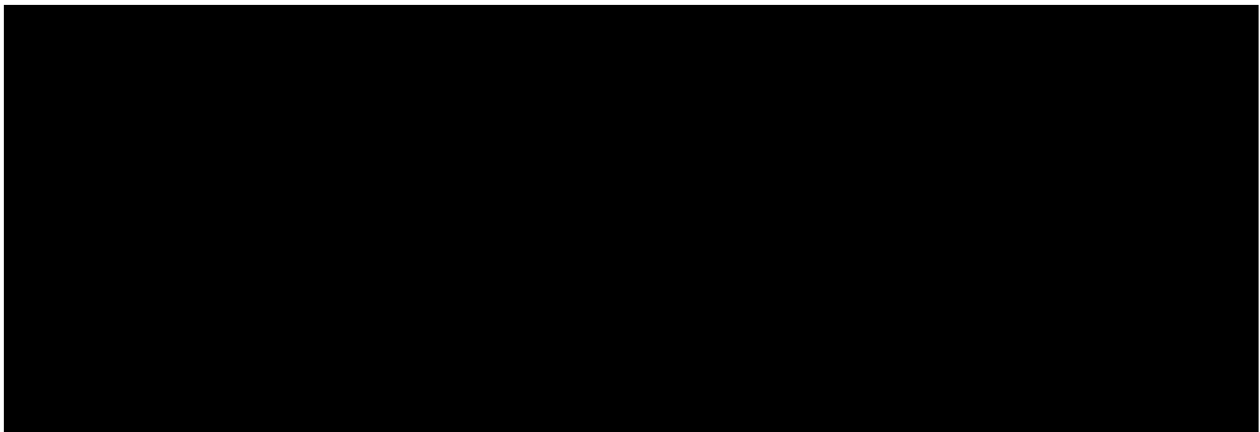
Applicant:

Research team:



MECHANO-CHEMICAL CARBONATION FOR CEMENTING CO₂ IN CONCRETE

1. Introduction



1.2. State of the art



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5. Research team and collaboration
5.1. Research team

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Other co-workers as technical staff (including but not limited to Ing. David Dvořák) will also be involved for routine material analyses, preparation of samples, compilation of protocols, and so on.

Each of the two partners has a deep knowledge in sustainable building materials. The applicant comes from the research-oriented university, while the co-organization is a well-known institute for building materials in the Czech Republic. Their close collaboration is therefore essential to carry out the project and successfully achieve the intended aims.

5.2. Equal opportunities and RRI

At VSB - Technical University of Ostrava (TUO), equal opportunities are upheld in all workplaces. TUO has crafted an ethical code in accordance with the European Commission recommended European Charter for Researchers.

The research team will focus on the environmental and social impacts of research under Responsible Research and Innovations (RRI). Given that this project features advanced carbon

neutrality technologies with ecological and environmental advantages, team members are convinced that the project outcomes align with and contribute to the concept of sustainable development.

5.3. Data treatment

The research data obtained in this project mainly consists of experimental data, and its processing will be in line with the best practices (work standards and ethical guidelines) in the field of civil engineering (basic research). In addition, a data management plan will be created at the start of the project, following the concept of open and fair data.

5.4. International collaboration

The research team has established a wide network of international collaborations in the field of civil engineering materials development and research, including:

- **Department of Civil, Environmental & Geomatic Engineering, University College London (UCL), UK** (Assoc. Prof. Mingzhong Zhang, h-index 46). Distinct expert on development of low carbon high-performance concrete using solid wastes, and multi-scale computational simulation.
- **Department of Civil and Environmental Engineering, Seoul National University, South Korea** (Prof. Juhyuk Moon, h-index 37). Distinct expert on accelerated carbon mineralization technology, especially the optimization design of carbonation device.
- **Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong** (Prof. Peiliang Shen, h-index 37). Long-term cooperation; Distinct expert on molecular scale reaction mechanism and carbonation kinetics analysis of wet carbonation.
- **School of Architecture, Seoul National University of Science and Technology, South Korea** (Prof. Sang-Keun Oh). Long-term cooperation; Experienced expert on design and standard establishment of green building materials.
- **School of Civil Engineering, Architecture and Environment, Hubei University of Technology, China** (Prof. Xingyang He, h-index 37). Long-term cooperation; Distinct expert on mechanochemical activation of solid wastes and its utilization in low carbon concrete.
- **Faculty of Civil Engineering and Geosciences, Delft University of Technology, the Netherlands** (Dr. Chen Liu). Skillful expert on thermodynamic modeling of low carbon cemented materials.



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Czech Science Foundation

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Research team: Ing. M. Drdlová; Ing. M. Nguyen; Ing. P. Bibora; S. Liu, MSc.; Ing. M. Pánek;
Ing. D. Dvořák

MECHANO-CHEMICAL CARBONATION FOR CEMENTING CO₂ IN CONCRETE

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