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REUSE OF RECYCLED ASPHALT PAVEMENT AND MINERAL SLUDGES IN FLUIDIZED THERMAL BACKFILLS

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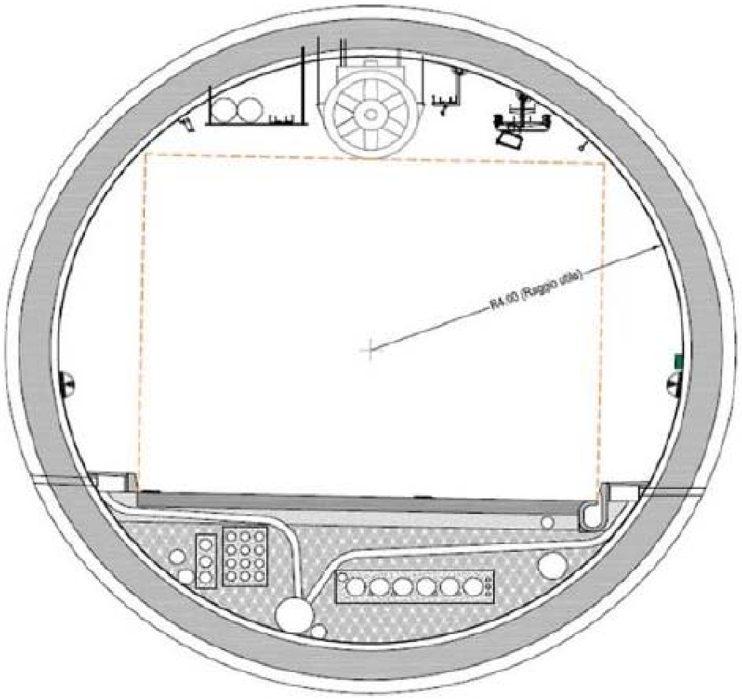
Context of the study



Second Tunnel at Frejus under construction

✓Buried Underground cables are used for the safe and reliable power transfer

✓Allowable temperature surrounding the cable is prescribed by the designers, heat dissipation influences efficiency of power transfer

✓Conventional backfill materials exhibit poor thermal conductivity

Fluidized Thermal Backfills (FTB)

Features

- High thermal conductivity and thermal stability
- Pumpability
- Self-levelling and self-compacting ability
- Sufficient strength and stiffness to protect buried cables
- A limit to maximum strength development

Design of FTB with recycled components

Steps adopted

- Identification of suitable raw materials
- Mix design
- Evaluation of flowability and thermal conductivity
- Identify the factors affecting performance of developed FTB

Recycled materials in FTB

- Low strength requirement in comparison to cement concrete
  - A limit to maximum strength development to facilitate future excavations
- Reuse of mineral sludges to improve the flowability
  - Mineral sludges to form the aggregate skeleton suitable for flowable mixes
- Cost and sustainability
  - Save virgin aggregates
  - Considerably reduces cost of materials
  - Accelerate the speed of construction
  - No compaction is required, reduces related emissions

Recycled Asphalt Pavement (RAP)

- Milling operation of damaged road pavements
  - According to available statistics, approximately 50 million and 73 million tons of RAP material are stockpiled every year in Europe and in the U.S
  - Growing landfill problems
  - Thin asphalt film around the aggregate
- Selection of suitable gradation is necessary

Mineral sludges

1. Aggregate sludge (AS)
2. Stone cutting sludge - Frame wire (SS-F)
3. Stone cutting sludge - Diamond Disc (SS-D)

High water content
Presence of heavy metals
No method for wide reuse is identified

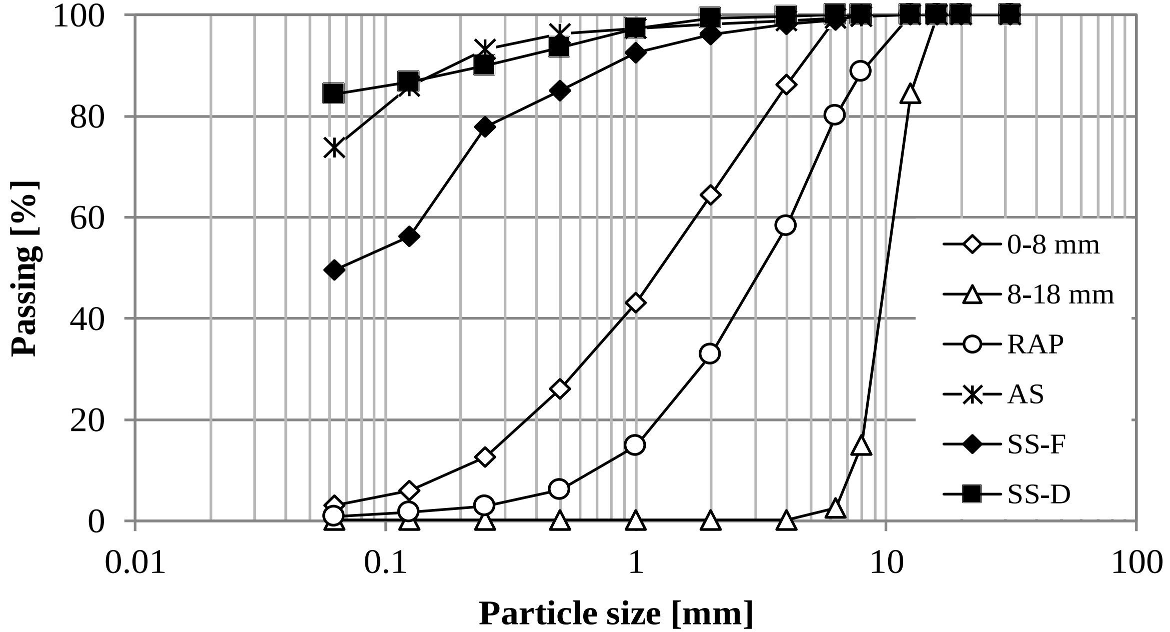
Frame wire saw

Washing of aggregates

Dried aggregate sludge

Experimental investigation

Characterization of raw materials



Fractions	SG (g/cm^3)
0-8 mm	2.745
8-18 mm	2.733
RAP	2.527
AS	2.785
SS-F	2.954
SS-D	2.666
Portland cement	3.150

Sludge	Co [mg/kg]	Ni [mg/kg]	Cu [mg/kg]	Fe [%]	Cr [mg/kg]	Zn [mg/kg]	Pb [mg/kg]	W [mg/kg]
AS	23.9	88.7	43.1	27.2	143.9	89.7	19.8	39.8
SS-D	20.2	0.4	<0.1	4.1	3.0	17.5	28.9	5.6
SS-F	21.3	69.5	96.7	29.9	88.0	85.3	17.5	21.9

Lower than Italian legislation for use in industrial and commercial applications

Design of FTB mixtures

FTB mixtures	RAP [%]	Cement [kg/m³]	W/P [-]	Sludge [%]	0-8 mm [%]	8-18 mm [%]
AS-RAP20-C60-0.8	20	60	0.8	24	39	17
AS-RAP20-C80-0.8	20	80	0.8	24	39	17
AS-RAP20-C100-0.8	20	100	0.8	24	39	17
AS-RAP0-C100-0.8	0	100	0.8	21	57	22
AS-RAP15-C100-0.8	15	100	0.8	23	44	18
AS-RAP30-C100-0.8	30	100	0.8	25	31	14
AS-RAP20-C100-0.75	20	100	0.75	24	39	17
AS-RAP20-C100-0.7	20	100	0.7	24	39	17
SS-D-RAP20-C100-0.7	20	100	0.7	23	40	17
SS-D-RAP20-C100-0.8	20	100	0.8	23	40	17
SS-F-RAP20-C100-0.7	20	100	0.7	32	30	18
SS-F-RAP20-C100-0.8	20	100	0.8	32	30	18

Recycled materials up to 55% in the aggregate skeleton

- ## Laboratory evaluation of FTB

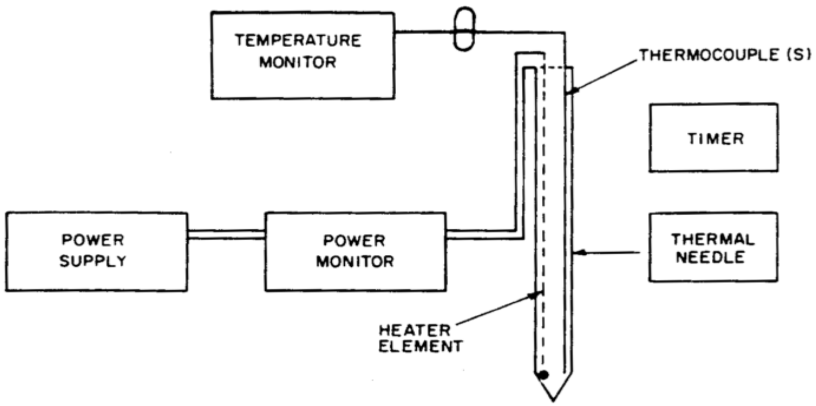
Flowability

At least 200mm in diameter without noticeable segregation

Flow consistency test ASTM D 6103

Segregated mixture

Thermal conductivity



ASTM D 5334 – thermal needle probe

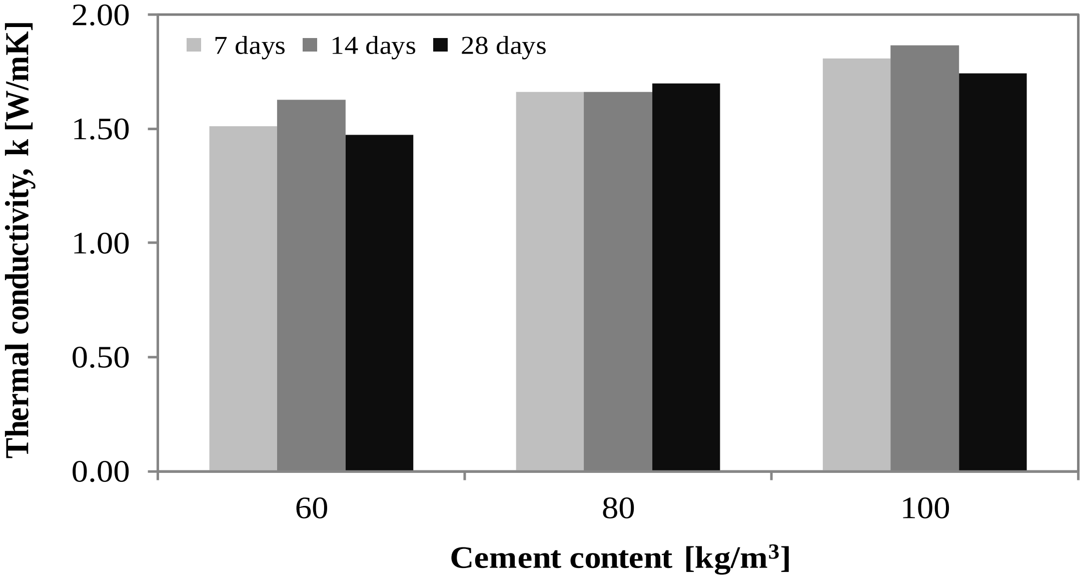
Thermal conductivity measurement

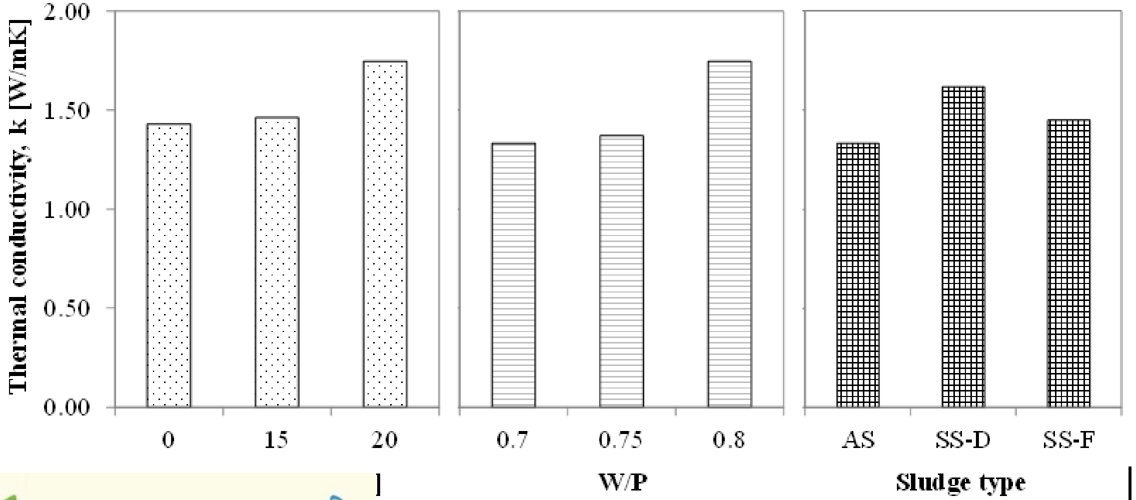
Results and Discussions

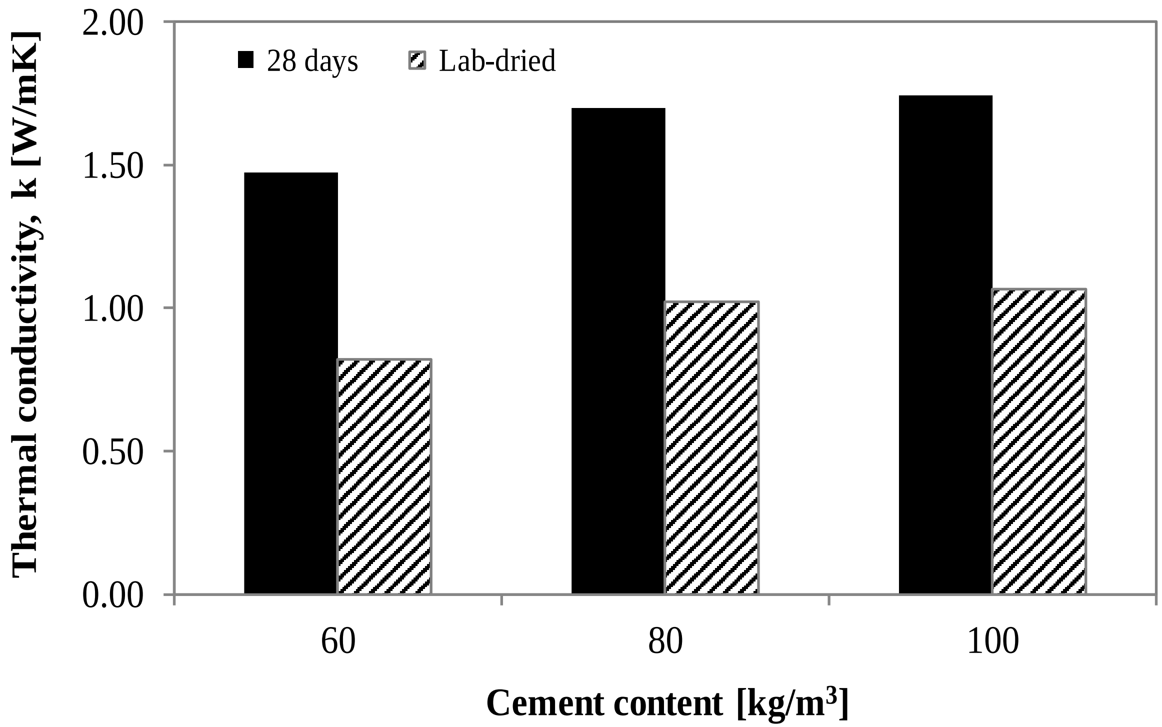
Flowability

FTB mixtures	D_s [mm]
AS-RAP20-C60-0.8	213
AS-RAP20-C80-0.8	225
AS-RAP20-C100-0.8	235
AS-RAP0-C100-0.8	204
AS-RAP15-C100-0.8	222
AS-RAP30-C100-0.8	-
AS-RAP20-C100-0.75	225
AS-RAP20-C100-0.7	210
SS-D-RAP20-C100-0.7	240
SS-D-RAP20-C100-0.8	-
SS-F-RAP20-C100-0.7	260
SS-F-RAP20-C100-0.8	-

Thermal conductivity







•Very low moisture content reached in lab-dried conditions led to a significant reduction of thermal conductivity.

• Values recorded in these limiting conditions were still compatible with typical design requirements, which indicate 0.8 W/mK as the recommended minimum limit.

• Dense packing of the aggregate skeleton comprised in the considered FTB mixtures and to the presence of a highly conductive hydrated cement paste

Conclusions

- Fluidized Thermal Backfills (FTBs) containing significant quantities of recycled materials can be successfully designed by ensuring satisfactory flowability and thermal conductivity properties
- Observed effects of composition variables should be taken into account in the development of further studies.

Future works

- Specific measurements for the assessment of the leaching of heavy metals from FTB
- Effect of cement in immobilization of heavy metals
- Reuse of quartzite quarry waste in FTB to improve the thermal conductivity

Way forward!

Lime stabilization of sludge for drying

Large scale production

Site trials

THANK YOU