Development of Operating Windows for Treatment of Industrial Wastes Using Blended Binder Systems

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Background (1)

- Stabilisation/solidification(S/S) is an option for treatment of residual wastes prior to disposal or utilisation
- Comprehensive testing of S/S formulations for different waste is expensive and time-consuming
- Wastes from similar process are likely to have similar properties
- UCL is leading a UK collaborative project (ProCeSS) to develop operating windows for S/S good practice

Background (2)

- A paper[1] has been published on screening tests for assessing treatability and threshold values are proposed
- This presentation proposes a method to develop operating windows and presents its application for S/S of metal treatment sludges

[1]J.A. Stegemann, Q. Zhou. Screening testes for assessing treatability of inorganic industrial wastes by stabilisation/solidification with cement, Journal of Hazardous Materials, 161 91), 300-306.

ProCeSS - Consortium

Consortium Leader
University College London

Universities
Birkbeck College
Cambridge University
Imperial College London
Surrey University

Government
UK Technology Strategy Board (www.innovateuk.org)
CL: AIRE
UK Environment Agency
CIRIA

Consultants/Contractors
May Gurney
Scott Wilson
White Young Green Environmental
WRc

Waste Generators
Corus
Surface Engineering Association

Waste Management
Grundon
SELCHP
Sita UK
Veolia Environmental Services

Materials Suppliers
British Cement Association
British Lime Association
CIRIA
Cementitious Slag Makers Association
The Concrete Centre
Elkem Materials
UKQAA

ProCeSS

Candidate Waste Types

- Metal treatment sludges from metal treatment industry
- Air Pollution Control residues from municipal solid waste incineration
- Air Pollution Control residues from the iron and steel industry
- Contaminated soil

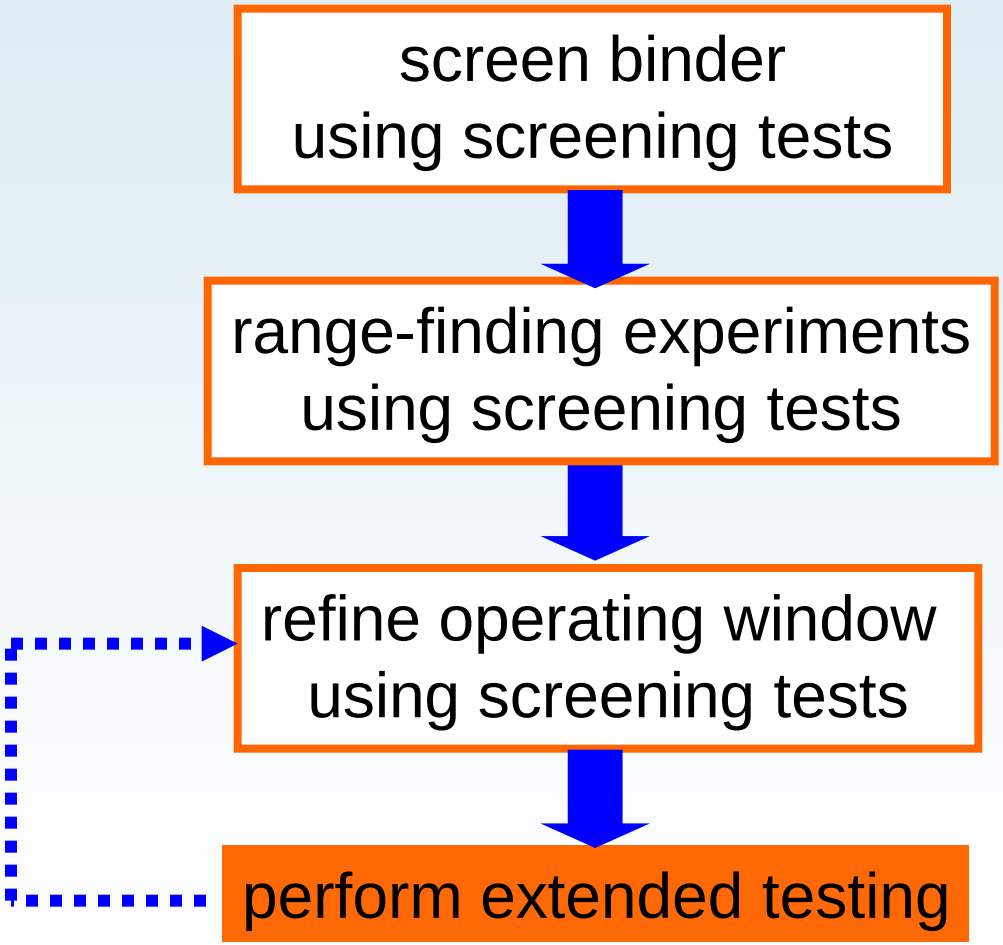
Candidate Binders

- Portland Cement
- Pulverised Fuel Ash (PFA)
- Ground Granulated Blastfurnace Slag (GGBS)
- Silica Fume
- Lime

Screening Tests and Threshold Values

Screening tests	Threshold values
• Consistence (BS EN 1015-3:1999)	Flow >175mm
• Bleeding	< 1% of total water at 24h
• Setting time (BS EN 196-3:2005)	2h<initial<8h, final<24h
• Unconfined Compressive Strength (BS EN 196-1:2005)	>1MPa at 28d $UCS_{after} \geq UCS_{before}$ immersion
• pH at 0 acid addition (DD CEN/TS 15364:2006)	11.9 ≤ pH ≤ 12.2 at 28d
• Hydraulic conductivity (ASTM D5084-03 method D)	$<1x10^{-9}$ m/s at 28d

Development of Operating Window (2)



without waste

high/low water addition
binder minimisation

Vary waste & binder proportions in factorial design experiments

Range-finding

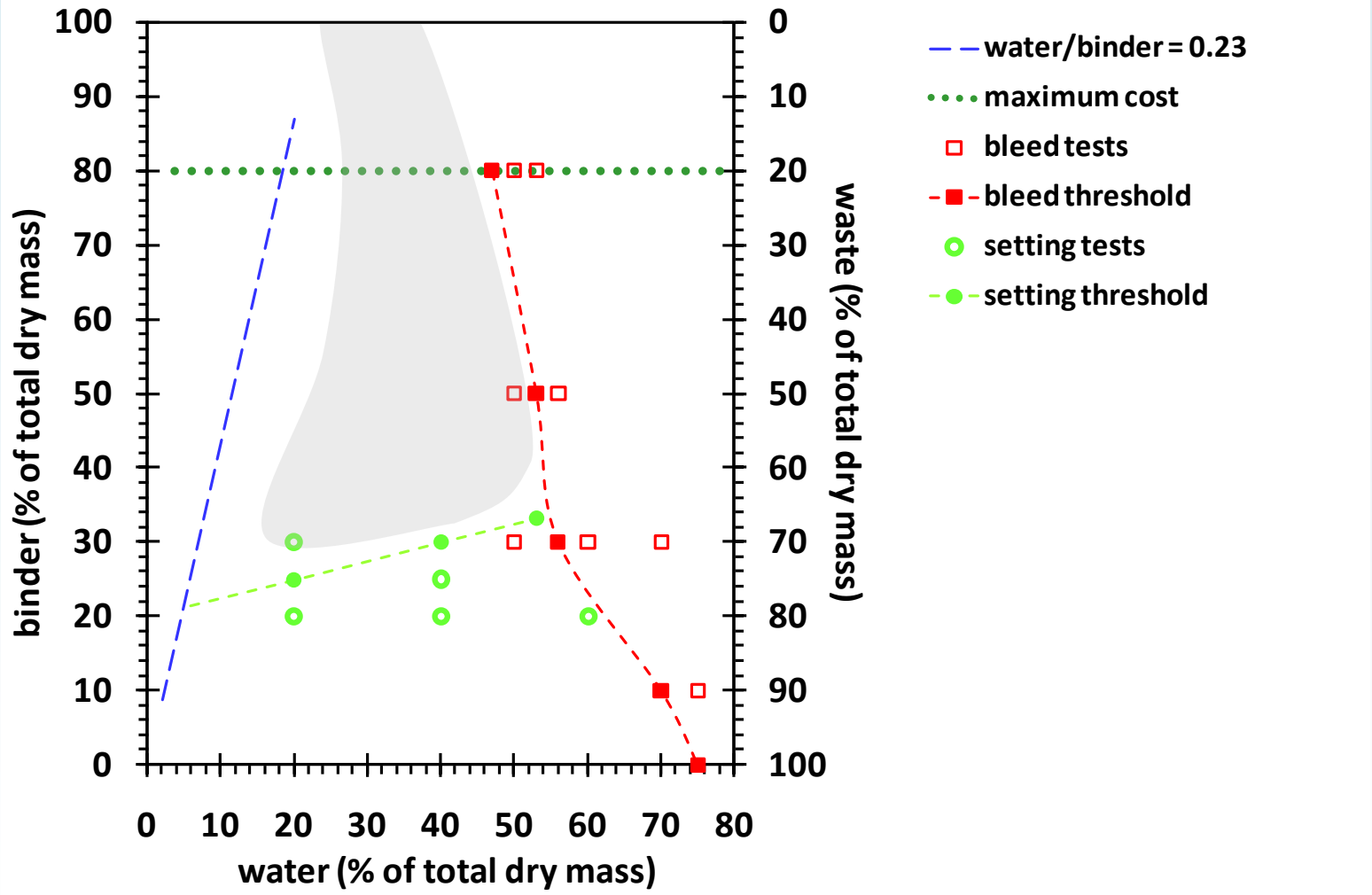


Fig.1 Hypothetical operating window with illustration of range-finding method

Operating Window Refinement

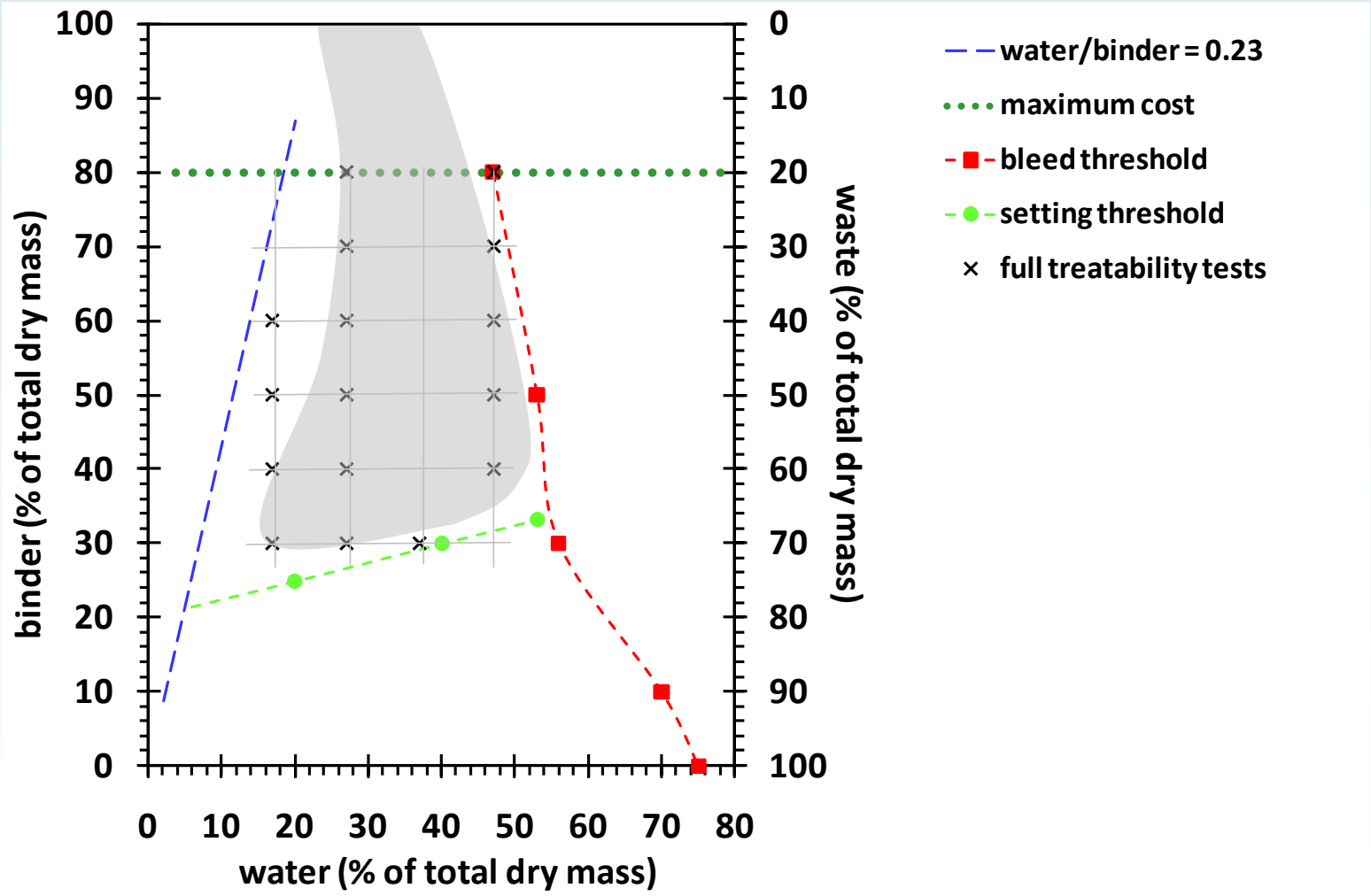


Fig.2 Hypothetical operating window with illustration of operating window refinement

An example of using proposed method to metal treatment sludges

Metal Treatment Sludges

- Metal treatment sludges were produced by filterpressing of sludges resulting from neutralisation of plating wastes with lime.
- Two types of them (ST5 and TX2) were received moist (50-80% moisture content), visible heterogeneous
- To obtain representative results, they were dried, crushed and homogenised for storage and reconstituted with water 24h before preparation.
- Both contain several hundreds to ten of thousands of mg/kg of a variety of metals, with concentrations of TX2 up to an order of magnitude higher than those in ST5

  (notably Al, Cr, Cu, Sn, Sb, and Zn)

Materials

- 2 binders
  - CEMI:ggbs = 1:0, 1:1, 1:2, 1:9
  - CEMI:pfa = 1:1, 1:2, 1:4, 1:9

- 2 metal treatment sludges
  - TX2 (high in all metals), water/binder = 0.6
  - ST5 (high in Ni), water/binder = 0.5

Minimum Water Addition (flowable consistence)

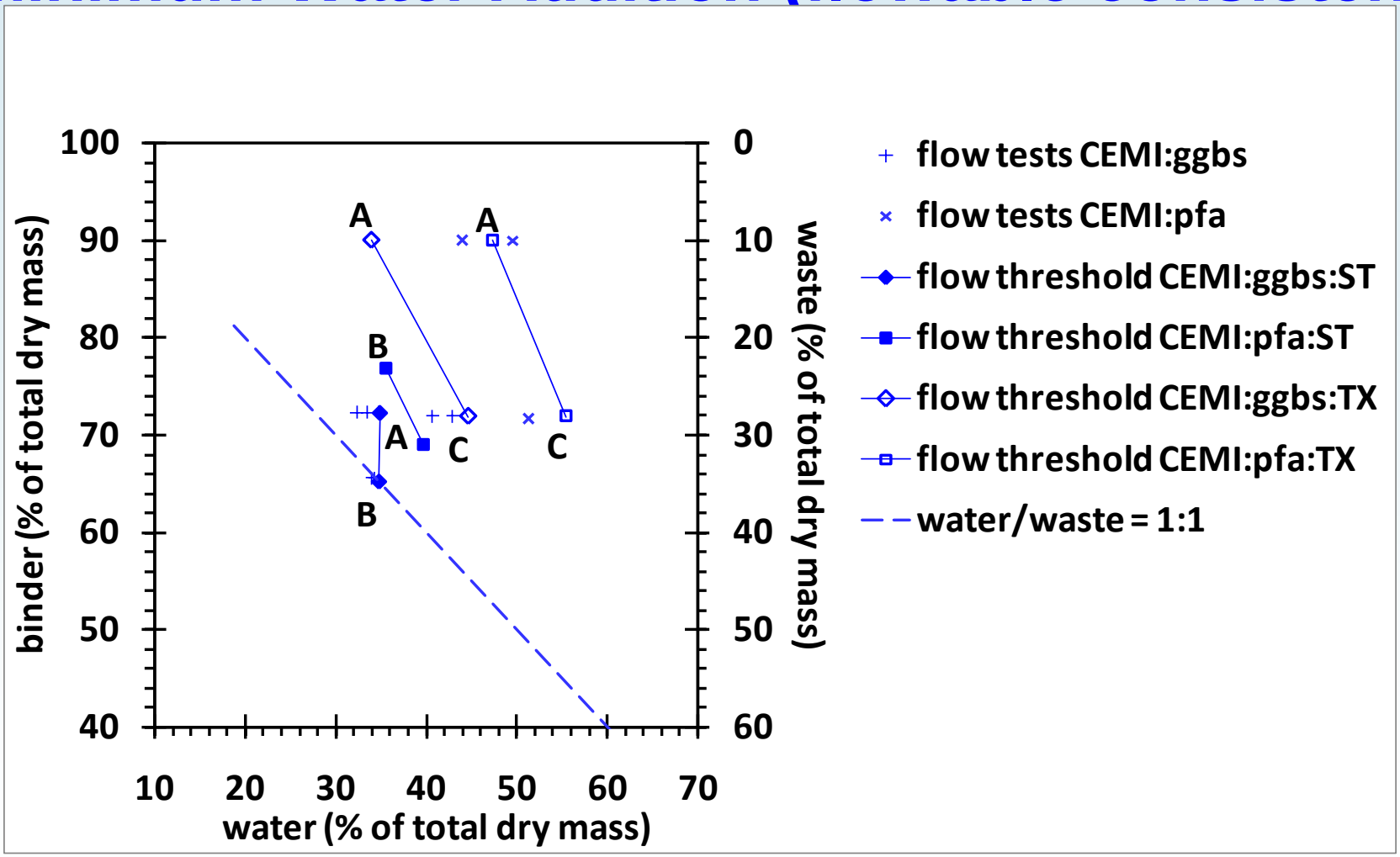


Fig.3 Determination of minimum water addition for S/S of metal treatment sludges

Maximum Water Addition (bleeding)

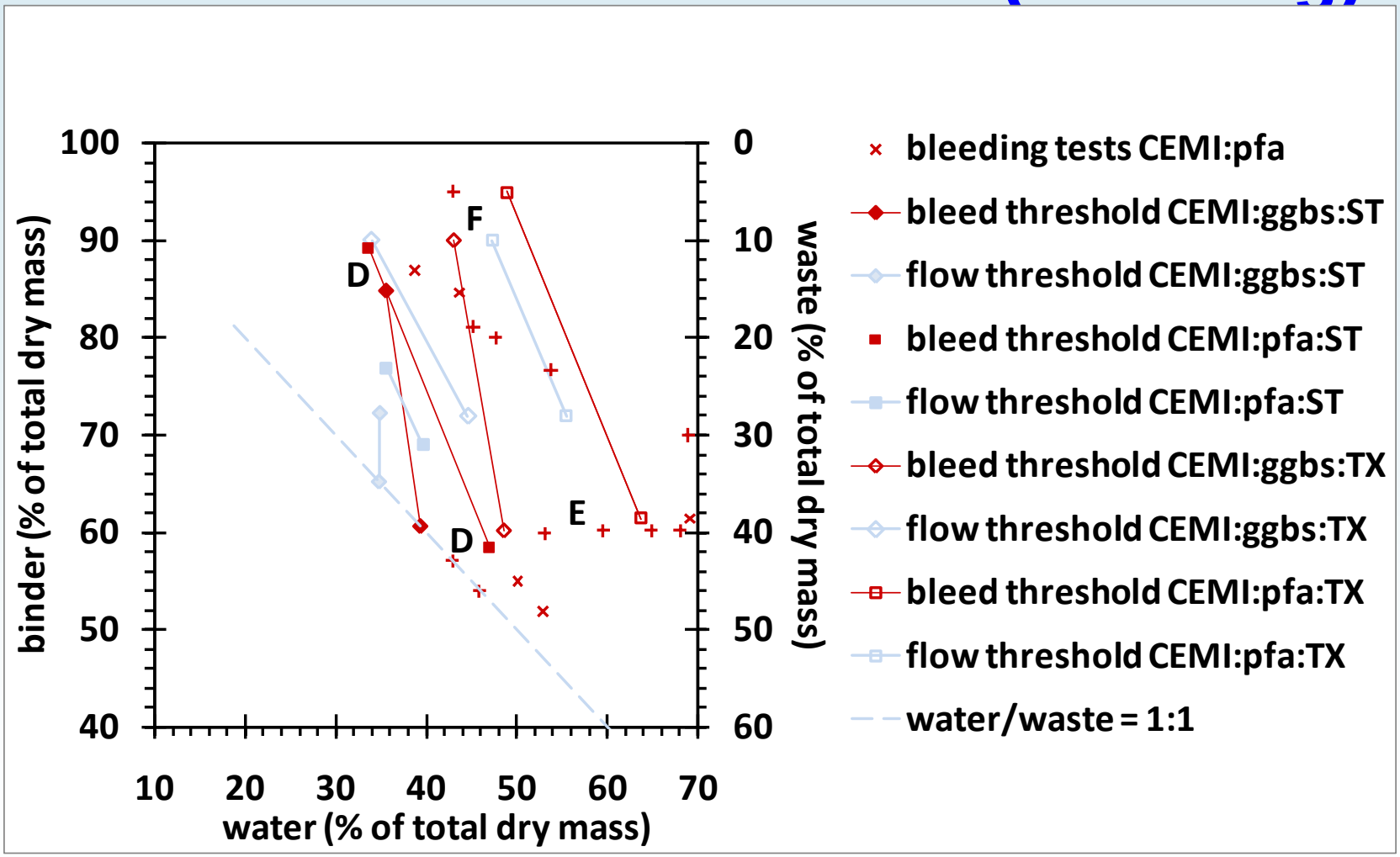


Fig.4 Determination of maximum water addition for S/S of metal treatment sludges

Operating Window

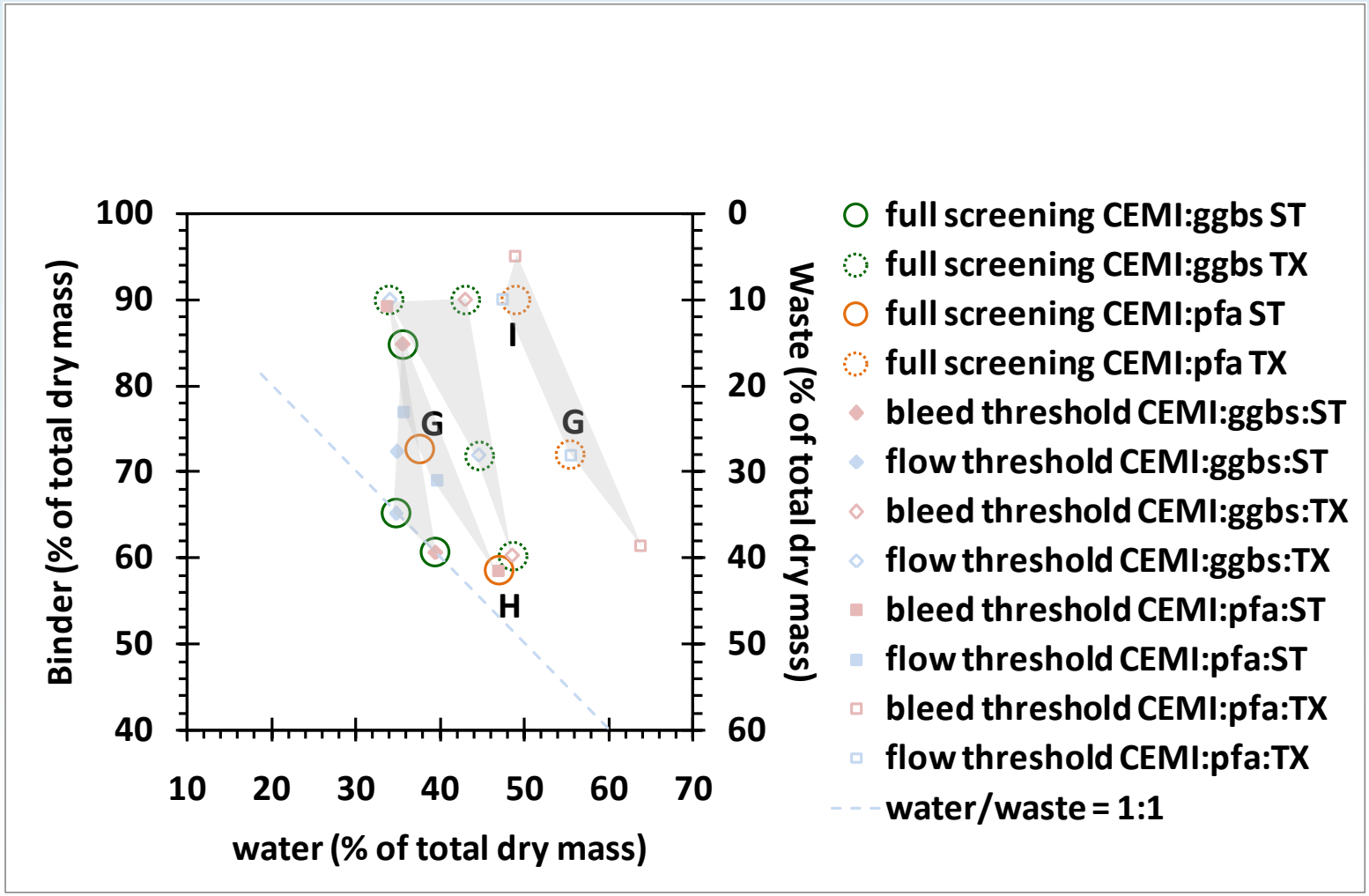


Fig. 5 Application of method to find operating window range for S/S of metal treatment sludges

Operating Window Refinement (1)

Full sets of screening tests as well as extended tests were applied to asses the compliance of these formulations with the proposed thresholds:

- The setting times of all formulations were within the desired range; both sludges reduced the setting time relative to the control.
- Formulations at the consistence threshold met the UCS threshold of 1MPa after 28d
- Formulations at the bleeding threshold near or below the UCS thrsdhold
- Formulations with wastes didn't achieve hydraulic conductivity threshold of 10^{-9} m/s. They failed in most of the mixes up to two magnitude.

Operating Window Refinement (2)

- The pH values measured for deioned water extracts of these formulations tended to be below 12.3, indicating the absence of free lime, as intended
- Statistical analysis is under way to understand the influence of variables on performance.

Summary (1)

- A method is proposed to apply to a wide range of circumstances for development of operating windows for treatment of industrial waste using blended binder systems
- Application of the method to treat metal treatment sludges appeared more complicated than hoped
- The results indicate that an operating window for this type of waste comprises only a very narrow range of water addition, mainly due to its high original moisture content.

Summary (2)

- Hydraulic conductivity failed in most of the mixes up to two magnitude. It may not be feasible to achieve lower hydraulic conductivities at the high water/binder ration used in this work.
- The s/s products are prepared based on systematic variation of the proportions of water and binder. Statistic analysis is conducted to develop a relatively complete understanding of the characteristics of the s/s products within the operating window.

Acknowledgement

- Founded by UK Technology Strategy Board
- Participation and support by 21 partners

http://www.cege.ucl.ac.uk/ process