

# Metodyka prowadzenia seryjnych oznaczeń laboratoryjnych efektywnej przewodności termicznej gruntów mineralnych

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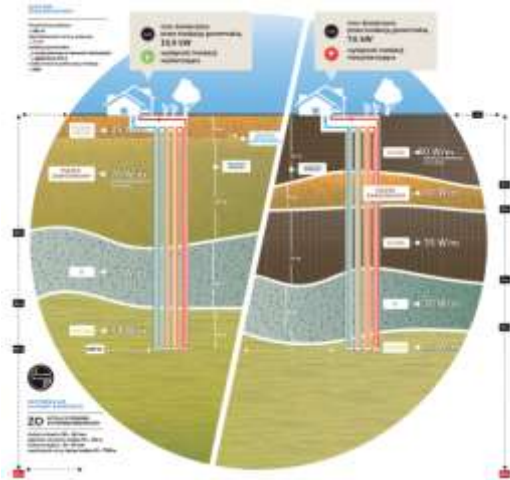


# Zastosowanie badań właściwości termicznych gruntów

Współczynnik przewodzenia ciepła  $\lambda$  [W/m·K]

## Geotermia niskotemperaturowa

- pompy ciepła
- termoaktywne elementy posadowienia budowli



Składowiska odpadów radioaktywnych

## Infrastruktura przesyłowa



# Procedury laboratoryjne

- PB-102/CBGS Właściwości termiczne gruntów spoistych
- PB-103/CBGS Właściwości termiczne gruntów niespoistych

Dokumenty źródłowe i założenia metody

- IEEE 442-2017 - IEEE Guide for Thermal Resistivity Measurements of Soils and Backfill Materials;

- ASTM D5334-14 - Standard Test Method for Determination of Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe Procedure

# Sprzęt i oznaczane parametry

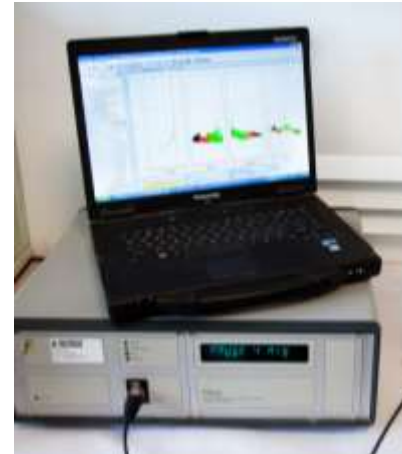
## Metoda igły termicznej w stanie nieustalonym

- przewodność termiczna  $K$  [ $W/m \cdot K$ ]
- pojemność cieplna  $C$  [ $mJ/m^3K$ ]
- oporność termiczna  $Rho$  [ $K \cdot m/W$ ]

**Analizator właściwości termicznych KD2 Pro**



**Analizator właściwości termicznych Tempos**



**Miernik przewodności termicznej TK04**

# Wykonywanie oznaczeń laboratoryjnych efektywnej przewodności termicznej gruntów spoistych



**Badania właściwości fizycznych zgodnie z normami PN-B i PN-EN ISO, w tym:**

- wilgotność naturalna
- skład granulometryczny
- gęstość objętościowa
- parametry stanu / konsystencji
- zawartość substancji organicznej

# Wykonywanie oznaczeń laboratoryjnych efektywnej przewodności termicznej gruntów niespoistych

**Badania właściwości fizycznych zgodnie z normami PN-B i PN-EN ISO, w tym:**

- wilgotność inicjalna
- skład granulometryczny
- gęstość objętościowa
- zawartość substancji organicznej

**Podpróbka o naturalnej wilgotności (NW)  
formowana w cylindrze**

3 stopnie zagęszczenia:  
luźny ( $I_p \leq 0,33$ )  
średniozagęszczony ( $0,33 < I_p \leq 0,67$ )  
zagęszczony ( $I_p > 0,67$ )

cykl pomiarowy właściwości termicznych  
(3 pomiary)

**Podpróbka wysuszona do stałej masy  
formowana w cylindrze**

3 stopnie zagęszczenia:  
luźny ( $I_p \leq 0,33$ )  
średniozagęszczony ( $0,33 < I_p \leq 0,67$ )  
zagęszczony ( $I_p > 0,67$ )

cykl pomiarowy właściwości termicznych  
(3 pomiary)

**Podpróbka w pełni nasycona wodą  
formowana w cylindrze**

3 stopnie zagęszczenia:  
luźny ( $I_p \leq 0,33$ )  
średniozagęszczony ( $0,33 < I_p \leq 0,67$ )  
zagęszczony ( $I_p > 0,67$ )

cykl pomiarowy właściwości termicznych  
(3 pomiary)

# Przygotowanie próbek gruntów do laboratoryjnych pomiarów właściwości termicznych

- Do czasu badania i na czas jego trwania próbki o naturalnej wilgotności oraz nawodnione powinny być szczelnie zamknięte i przebywać w urządzeniu chłodniczym.
- Formowanie gruntu należy prowadzić w taki sposób, aby właściwości fizyczne charakteryzujące uzyskaną próbkę były jak najbliższe parametrom gruntu in situ (wartości literaturowe).
- Próbkę należy odstawić do inkubatora termicznego/pomieszczenia, w którym będzie wykonywane badanie na min. 24 h przed rozpoczęciem pomiarów.
- Pomiary przy zadanej stałej temperaturze.



Inkubator termiczny



Pomiar urządzeniem KD Pro w inkubatorze termicznym

# Formowanie próbek gruntów niespoistych





# Formowanie próbek gruntów spoistych



# Pomiary właściwości termicznych

- Przed rozpoczęciem serii pomiarów należy wykonać pomiar testowy z użyciem certyfikowanego materiału wzorcowego dostarczonego przez producenta – sprawdzenie poprawności działania sprzętu.
- Sondę należy wprowadzić w całości w centralną część powierzchni ścięcia próbki, tak, aby z każdej strony między próbką a ścianą naczynia pozostało minimum 2 cm gruntu.
- Rozpocząć procedurę pomiarową. Powtórzyć pomiary minimum 3 razy na każdej próbce, nie zmieniając położenia igły.
- Minimalny odstęp między kolejnymi pomiarami powinien wynosić 15 minut.



Pomiar testowy z użyciem certyfikowanego materiału wzorcowego

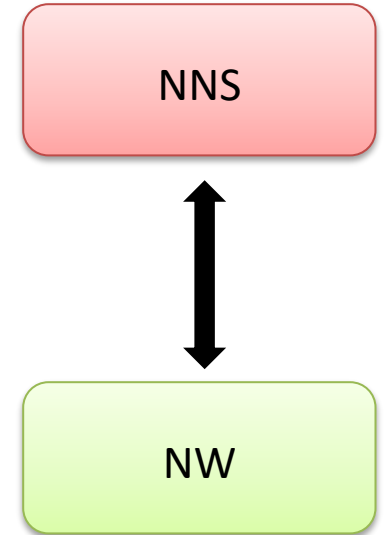
# Kontrola jakości wyników



Pomiar właściwości termicznych gruntu laboratoryjnym miernikiem TK04



Pomiar właściwości termicznych gruntu w terenie

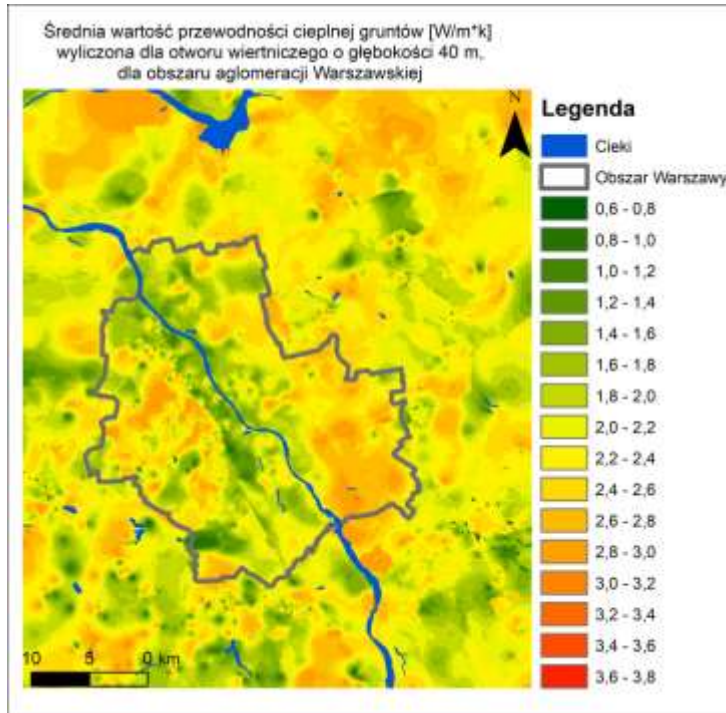


# Baza danych właściwości termicznych gruntów

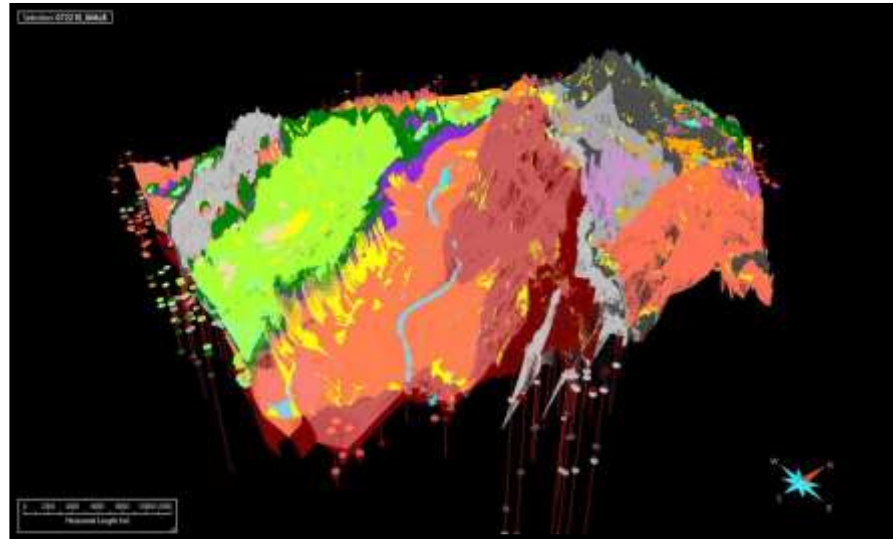
The screenshot displays a Microsoft Access database window titled "Baza danych właściwości termicznych gruntów". The interface is divided into several panes:

- Navigation Pane (Left):** Shows a hierarchical view of the database structure, including tables like "TABLIS", "TABLIS\_AK", "TABLIS\_G", "TABLIS\_M", "TABLIS\_S", "TABLIS\_T", "TABLIS\_W", "TABLIS\_X", "TABLIS\_Y", "TABLIS\_Z", "TABLIS\_AA", "TABLIS\_AB", "TABLIS\_AC", "TABLIS\_AD", "TABLIS\_AE", "TABLIS\_AF", "TABLIS\_AG", "TABLIS\_AH", "TABLIS\_AI", "TABLIS\_AJ", "TABLIS\_AK", "TABLIS\_AL", "TABLIS\_AM", "TABLIS\_AN", "TABLIS\_AO", "TABLIS\_AP", "TABLIS\_AQ", "TABLIS\_AR", "TABLIS\_AS", "TABLIS\_AT", "TABLIS\_AU", "TABLIS\_AV", "TABLIS\_AW", "TABLIS\_AX", "TABLIS\_AY", "TABLIS\_AZ", "TABLIS\_BA", "TABLIS\_BB", "TABLIS\_BC", "TABLIS\_BD", "TABLIS\_BE", "TABLIS\_BF", "TABLIS\_BG", "TABLIS\_BH", "TABLIS\_BI", "TABLIS\_BJ", "TABLIS\_BK", "TABLIS\_BL", "TABLIS\_BM", "TABLIS\_BN", "TABLIS\_BO", "TABLIS\_BP", "TABLIS\_BQ", "TABLIS\_BR", "TABLIS\_BS", "TABLIS\_BT", "TABLIS\_BU", "TABLIS\_BV", "TABLIS\_BW", "TABLIS\_BX", "TABLIS\_BY", "TABLIS\_BZ", "TABLIS\_CA", "TABLIS\_CB", "TABLIS\_CC", 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"TABLIS\_XY", "TABLIS\_XZ", "TABLIS\_YA", "TABLIS\_YB", "TABLIS\_YC", "TABLIS\_YD", "TABLIS\_YE", "TABLIS\_YF", "TABLIS\_YG", "TABLIS\_YH", "TABLIS\_YI", "TABLIS\_YJ", "TABLIS\_YK", "TABLIS\_YL", "TABLIS\_YM", "TABLIS\_YN", "TABLIS\_YO", "TABLIS\_YP", "TABLIS\_YQ", "TABLIS\_YR", "TABLIS\_YS", "TABLIS YT", "TABLIS YU", "TABLIS YV", "TABLIS YW", "TABLIS YX", "TABLIS YZ", "TABLIS\_ZA", "TABLIS\_ZB", "TABLIS\_ZC", "TABLIS\_ZD", "TABLIS\_ZE", "TABLIS\_ZF", "TABLIS\_ZG", "TABLIS\_ZH", "TABLIS\_ZI", "TABLIS\_ZJ", "TABLIS\_ZK", "TABLIS\_ZL", "TABLIS\_ZM", "TABLIS\_ZN", "TABLIS\_ZO", "TABLIS\_ZP", "TABLIS\_ZQ", "TABLIS\_ZR", "TABLIS\_ZS", "TABLIS\_ZT", "TABLIS\_ZU", "TABLIS\_ZV", "TABLIS\_ZW", "TABLIS\_ZX", "TABLIS\_ZY", "TABLIS\_ZZ".
- Table Design View (Center):** Shows the structure of the "TABLIS\_AK" table. Fields include: "ID" (Number), "KOD" (Text), "KOD2" (Text), "KOD3" (Text), "KOD4" (Text), "KOD5" (Text), "KOD6" (Text), "KOD7" (Text), "KOD8" (Text), "KOD9" (Text), "KOD10" (Text), "KOD11" (Text), "KOD12" (Text), "KOD13" (Text), "KOD14" (Text), "KOD15" (Text), "KOD16" (Text), "KOD17" (Text), "KOD18" (Text), "KOD19" (Text), "KOD20" (Text), "KOD21" (Text), "KOD22" (Text), "KOD23" (Text), "KOD24" (Text), "KOD25" (Text), "KOD26" (Text), "KOD27" (Text), "KOD28" (Text), "KOD29" (Text), "KOD30" (Text), "KOD31" (Text), "KOD32" (Text), "KOD33" (Text), "KOD34" (Text), "KOD35" (Text), "KOD36" (Text), "KOD37" (Text), "KOD38" (Text), "KOD39" (Text), "KOD40" (Text), "KOD41" (Text), "KOD42" (Text), "KOD43" (Text), "KOD44" (Text), "KOD45" (Text), "KOD46" (Text), "KOD47" (Text), "KOD48" (Text), "KOD49" (Text), "KOD50" (Text), "KOD51" (Text), "KOD52" (Text), "KOD53" (Text), "KOD54" (Text), "KOD55" (Text), "KOD56" (Text), "KOD57" (Text), "KOD58" (Text), "KOD59" (Text), "KOD60" (Text), "KOD61" (Text), "KOD62" (Text), "KOD63" (Text), "KOD64" (Text), "KOD65" (Text), "KOD66" (Text), "KOD67" (Text), "KOD68" (Text), "KOD69" (Text), "KOD70" (Text), "KOD71" (Text), "KOD72" (Text), "KOD73" (Text), "KOD74" (Text), "KOD75" (Text), "KOD76" (Text), "KOD77" (Text), "KOD78" (Text), "KOD79" (Text), "KOD80" (Text), "KOD81" (Text), "KOD82" (Text), "KOD83" (Text), "KOD84" (Text), "KOD85" (Text), "KOD86" (Text), "KOD87" (Text), "KOD88" (Text), "KOD89" (Text), "KOD90" (Text), "KOD91" (Text), "KOD92" (Text), "KOD93" (Text), "KOD94" (Text), "KOD95" (Text), "KOD96" (Text), "KOD97" (Text), "KOD98" (Text), "KOD99" (Text), "KOD100" (Text).
- Data Table View (Right):** Displays a grid of data for the "TABLIS\_AK" table. The columns correspond to the fields in the design view. The data includes numerical values for "ID" and "KOD" fields, and various text values for the remaining fields.

# Wizualizacja danych na mapach średniej wartości przewodności termicznej oraz modelach 3D podłoża



Model 3D powierzchni stropowych serii geotermalnych  
arkusza SMGP Jeleniej Góry



Metodyka badawcza została opracowana w PIG-PIB ramach zadania państwowej służby geologicznej (PSG) pod nazwą *Ocena potencjału energetycznego i uwarunkowań środowiskowych dla wsparcia zrównoważonego rozwoju geotermii niskotemperaturowej*, realizowanego w latach 2017-2021.



