A new technique for non-destructive field measurement of rock-surface strength: an application of the Equotip hardness tester to weathering studies

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Earth surface processes and landforms

volume 32

number 12

page range 1759-1769

year 2007-03

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URL http://hdl.handle.net/2241/97998
doi: 10.1002/esp.1492
Fig. 1

- Release button
- Impact device
- Rock surface
Fig. 2

The diagram illustrates the range of compressive strength (MPa) for different testing methods:

- Equotip hardness tester
- L-type Schmidt hammer
- Needle-type penetrometer
- Cone penetrometer
Aoshima Island
Yayoi Bridge
Studied pier
Spray zone
M. H. W. L.
Intertidal zone
M. S. L.

Fig. 3
Fig. 4
$L_{\text{max}} = 10.9R_{\text{max}} + 86.7$

$R = 0.754^*$

*Significant at 1% level.

Fig. 5
(a) $R_s = 0.55 R_{\max} + 10.8$
\[ R = 0.867^* \]
*Significant at 1% level.

(b) $L_s = 0.51 L_{\max} + 76.7$
\[ R = 0.511^* \]
*Significant at 1% level.
Fig. 7

Weathered surface

Split surface

Area B

Area A

(b) Weathered surface

Edge line

Split surface

1 mm

Fig. 7b

(a)
Fig. 8

Equotip rebound value, $L$

Weathered surface (single impacts)
Split surface (single impacts)

Weathered surface (repeated impacts)
Split surface (repeated impacts)

$L_{\text{max}} = 720$
$L_{\text{max}} = 716$

$L_s = 554$

$L_s = 450$

Number of impacts

300 400 500 600 700 800

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
$L_{\text{surface}} = \delta L_{\text{intact}}$

- $\delta = 1$
- $\delta = 0.9$
- $\delta = 0.8$
- $\delta = 0.76$
- $\delta = 0.7$
- $\delta = 0.67$
- $\delta = 0.6$

- $\triangle$ 1st and 2nd layers: intertidal zone
- $\blacktriangle$ 3rd layer (at MHWL): intertidal zone
- $\bigcirc$ 4th to 10th layers: spray zone

Fig. 9
Fig. 10

$L_{\text{surface}} = L_{\text{intact}}$

- $L_s = 324$
- $L_s = 361$

- 3rd layer (at MHWL)
- 4th to 10th layers: spray zone
Table I  Some physical and mechanical properties of sandstone from Aoshima (after Takahashi, 1975).

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Value</th>
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<tbody>
<tr>
<td>Apparent specific gravity</td>
<td>2.69</td>
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<tr>
<td>Bulk specific gravity</td>
<td>2.51</td>
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<tr>
<td>Porosity (%)</td>
<td>6.9</td>
</tr>
<tr>
<td>Maximum water content (%)</td>
<td>2.5</td>
</tr>
<tr>
<td>Longitudinal wave velocity (km/sec)</td>
<td>3.16</td>
</tr>
<tr>
<td></td>
<td>dry*</td>
</tr>
<tr>
<td>Young's modulus ($\times 10^4$ MPa)</td>
<td>2.5</td>
</tr>
<tr>
<td>Compressive strength (MPa)</td>
<td>dry 99.0</td>
</tr>
<tr>
<td>Tensile strength (MPa)</td>
<td>dry 7.2</td>
</tr>
<tr>
<td>Shear strength (MPa)</td>
<td>dry 15.1</td>
</tr>
</tbody>
</table>

*dry: oven-dried  **wet: fully saturated
Table II  Location of sandstone block layer and the average depth ($D_{38}$) during 38 years for each layer (Takahashi et al., 1994).

<table>
<thead>
<tr>
<th>Altitude (cm)</th>
<th>Layer Number of blocks</th>
<th>Mean depth $D_{38}$ (cm)</th>
<th>Standard deviation $\sigma$</th>
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</thead>
<tbody>
<tr>
<td>251</td>
<td>10</td>
<td>9</td>
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<td>224</td>
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<td>9</td>
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<td>7</td>
<td>9</td>
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<td>9</td>
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<tr>
<td>8</td>
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