

Laporan Akhir Projek Penyelidikan Jangka Pendek

1. Nama Penyelidik: Mohamad Razip bin Selamat (Profesor Madya Dr. Ir.)
Nama Penyelidik Kedua: Hamidi Abdul Aziz (Profesor Madya Dr.)
2. Pusat Pengajian: Kejuruteraan Awam
3. Tajuk Projek Penyelidikan: THEORETICAL ELABORATION OF SOLID WASTE CONSOLIDATION AND DEVELOPMENT OF THE ASSOCIATED LABORATORY TESTING PROCEDURE
4. (a) Abstrak

Bahasa Malaysia

Ujian pengukuhan yang biasanya digunakan untuk menguji tanah liat bagi tujuan pembinaan tapak, telah dijalankan keatas komponen-komponen sisa pepejal perbandaran bagi menentukan sifat-sifat kejuruteraan yang berkaitan dengan kebolehkuatannya. Tegasan keatas sample ditingkatkan setiap 24 jam bagi jangka masa ujian diantara 4 hingga 7 hari dengan nilai setiap tambahan tegasan bersamaan dengan jumlah nilai tegasan yang dikenakan sebelumnya. Setelah mencapai tegasan maksimum, tegasan juga dikurangkan bagi mendapatkan lengkung balikan (rebound curve) – sebagaimana biasanya dilakukan keatas sample tanah. Bagi bahan-bahan bungkusan plastic, suatu ujian dengan 4 tambahan beban, dan tegasan dari mulanya 1.37 kPa sehingga akhirnya 40.5 kPa menyebabkan enapan 77% daripada tebal asal. Bagi bahan-bahan bungkusan surat khabar, 4 tambahan tekanan yang sama seperti sebelumnya telah menyebabkan penurunan tebal 59%. Bagi daging segar, 5 tambahan tegasan digunakan, yang menyebabkan sisa menyusut 29% dalam 5 hari. Bagi bahan ikan segar, 5 tambahan beban keatasnya menyebabkan enapan 67%. Bagi kangkung dan bayam, setelah lima tambahan beban, enapan berlaku 92% daripada ketebalan asal, atau hampir keseluruhannya. Bagi kulit pisang, sample mengecut 80% daripada tebal asal selepas 6 tambahan beban. Akhir sekali, bagi bahan nasi, sampel dapat dikurangkan ketebalannya sebanyak 33% daripada tebal asal dengan 5 tambahan beban. Keputusan keseluruhannya menunjukkan bahawa sekiranya bahan sisa boleh dikenakan tekanan selama kira-kira 4 hingga 6 hari sebelum dibuang ditempat kabus tanah, isipadunya dapat dikurangkan dengan banyaknya – suatu penjimatan yang amat bermakna

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bagi ruangan tempat pembuangan sampah kabus tanah. Keputusan juga menunjukkan amalan enapan yang berlaku di tempat pembuangan sampah – nilai ini diperlukan oleh pengendali kemudahan ini bagi tujuan perancangan. Ujian pengukuhan yang biasanya digunakan bagi tujuan kejuruteraan geoteknik tapak bina kini boleh juga digunakan bagi menganalisa enapan bahan sisa pepejal perbandaran.

Bahasa Inggeris

Consolidation tests, which commonly apply to clayey soils for foundation purposes, were conducted on elements of municipal solid waste samples in order to determine their engineering characteristics associated with their compressibility. Stresses were increased after every 24 hours for between 4 to 7 days with each stress increment roughly equaled to the stress being applied before placing the increment. Stresses were also decremented in order to observe the rebound curve – as always done to soil samples in an ordinary consolidation curve. For plastic wrappings, a test using 4 increments with stress ranging from the original 1.37 kPa to the final 40.5 kPa had caused a settlement of 77% of the original thickness. For newspaper wrappings, an equal 4-increment test had resulted in the reduction of 59% of the original thickness. For fresh meat, 5 increments were used but of the same stress range and resulted in the waste settling 29% in 5 days. For whole fish, the 5 increments applied on it had created 67% settlement. For spinach and kangkung, mixed, the 5 increments had caused the sample to settled almost completely or 92% of the original thickness. For banana skin, the sample had been reduced 80% of its original thickness in 6 increments. Finally, for rice, sample thickness was reduced 33% in 5 increments. The overall results had shown how much waste volume be reduced if only stress could be applied for between 4 to 6 days before disposal - which imply saving volume at waste disposal facilities. The results also indicate the amounts of settlement that is normally occurring at municipal landfills – the figures of which owners may use to plan the operation of their dumpsites. Consolidation test procedure, which commonly done in soil laboratory, is now applicable also in determining municipal solid waste consolidation characteristics.

(b) Senaraikan kata kunci yang digunakan di dalam abstrak

Bahasa Malaysia	Bahasa Inggeris
Enapan Bahan Sisa	Waste Consolidation
Sisa Pepejal Perbandaran	Municipal Solid Waste
Kabus Tanah	Landfills

5. Output Dan Faedah Projek

(a) Penerbitan

Sedang disediakan. Himpunan data (data compilation) disertakan

(b) Faedah-faedah lain

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(c) Latihan Gunatenaga Manusia

- i. Pelajar Siswazah. Seorang pelajar siswazah peringkat sarjana, Wan Norlida binti Wan Wok, dari UiTM Perlis, mengambil tajuk penyelidikan ini bagi kerja penyelidikan beliau. Wan Norlida telah mendaftar di Pusat Pengajian Kejuruteraan Awam dengan penyelidik menjadi penyelia beliau.
- ii. Pelajar prasiswazah. Lester Wong Tze Vui telah menjalankan projek tahun akhir beliau dengan tajuk yang berkaitan dengan penyelidikan ini. Tajuk beliau ialah 'Ujian Kebolehtelapan Sisa Pepejal Sedang Terkukuh'. Beberapa helaian daripada laporan projek beliau disertakan bersama.
- iii. Lain-Lain. Seorang pelajar pra-siswazah telah dilantik menjadi 'pembantu penyelidik' dengan gaji harian RM15 untuk selama beberapa bulan dan beliau telah belajar beberapa ciri bekerja sebagai penyelidik. Dua orang lagi remaja tempatan lepasan SPM telah diambil bekerja sebagai pembantu penyelidik untuk selama beberapa bulan dan kedua-dua remaja ini juga telah belajar beberapa ciri bekerja sebagai penyelidik.

6. Peralatan Yang Telah Dibeli.

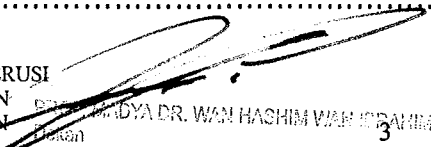
Sebuah 'waste consolidometer' telah ditempah oleh penyelidik dan telah dibina oleh kontraktor tempatan dengan harga RM1500.00. 'Waste Consolidometer' ini direkabentuk oleh penyelidik sendiri.

UNTUK KEGUNAAN JAWATANKUASA PENYELIDIKAN UNIVERSITI

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T/TANGAN PENERUSI
J/K PENYELIDIKAN
PUSAT PENGAJIAN


DYA DR. WAN HASHIM WAN IDRIS
Pusat Pengajian Kejuruteraan Awam
Kampus Kejuruteraan
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Pulau Pinang.

PARTIAL REPORT:

THEORETICAL ELABORATION OF SOLID WASTE CONSOLIDATION AND DEVELOPMENT OF THE ASSOCIATED LABORATORY TESTING PROCEDURE

1. An equipment to test the compressibility (consolidation characteristics) of municipal solid has been designed (Fig. 1) and fabricated.
2. Consolidation tests using the fabricated equipment have attempted on various types of municipal solid waste namely vegetable, meat, fish, rice, plastic bags, and newspaper. It was found that given a one week consolidation period, most waste can be compressed to an amount much smaller than its original volume. While the good news is that waste can be compressed so much to save landfill volume, the bad news is that the compression period required is too long at one week.
3. A theoretical elaboration of solid waste consolidation has been developed. Take for example the effective stress - settlement curve of Fig. 2, the equation involving the compression index can be given by:

$$C_c = \frac{De}{\log \frac{s'_2}{s'_1}}$$

but due to the nature of solid waste it is difficult to determine its void ratio. What can be done is by appointing Δe as a function of thickness:

$$\Delta e = f(\Delta H) = b(H_1 - H_2)$$

where b is a constant associated with waste void ratio. Furthermore, if the final thickness can be assumed as the thickness of waste solid, void ratio can then be defined as:

$$e = \frac{H - H_f}{H_f}$$

where H_f is the final thickness. For Δe then:

$$\Delta e = e_1 - e_2 = \frac{H_1 - H_f - H_2 + H_f}{H_f} = \frac{H_1 - H_2}{H_f}$$

In the tests, H_f was readily available.

Permeability of waste during consolidation had also been investigated.

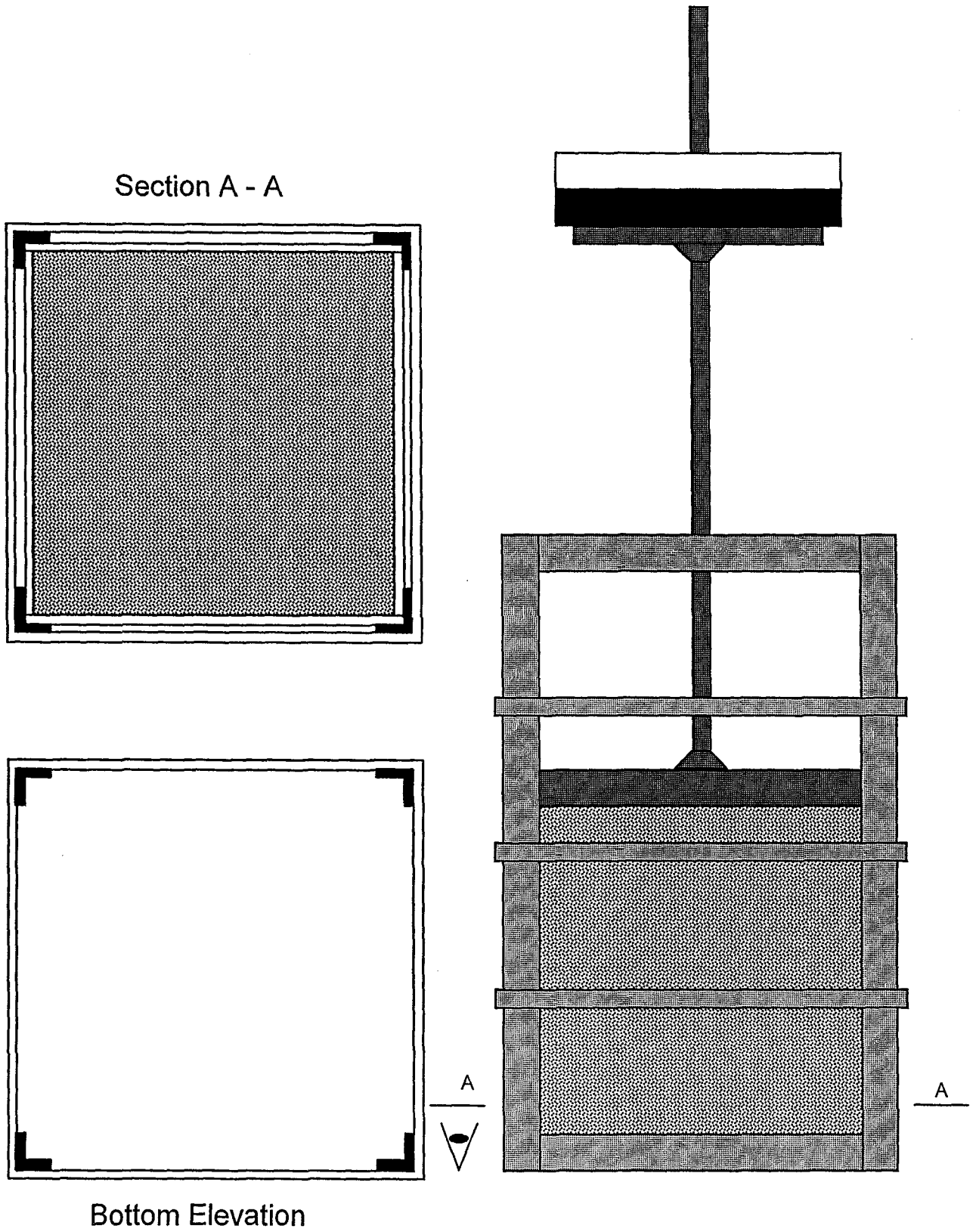
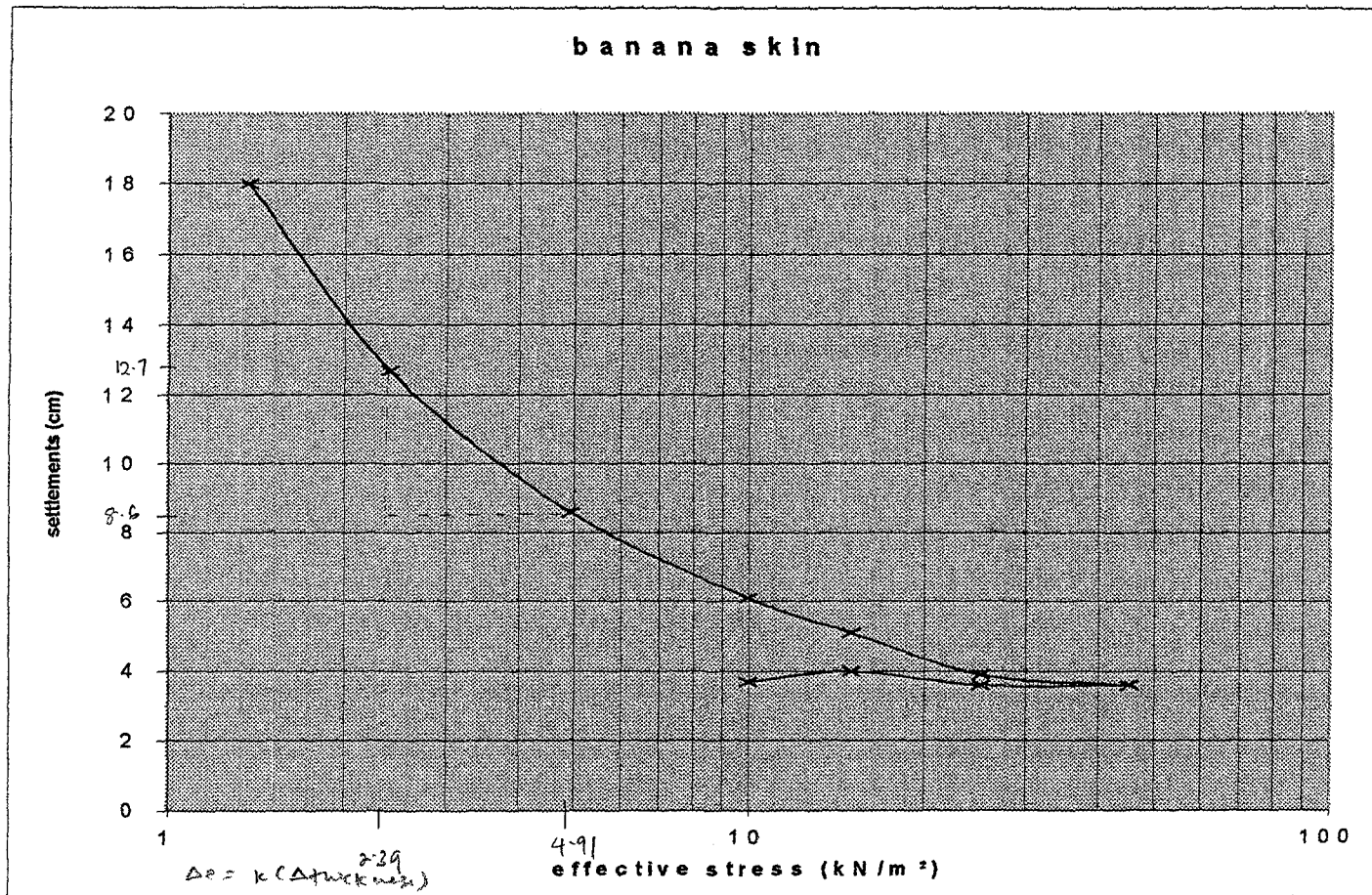


Fig. 1 - Waste Consolidometer

Some Research results



$$C_c = \frac{\Delta e}{\Delta \log \sigma'}$$

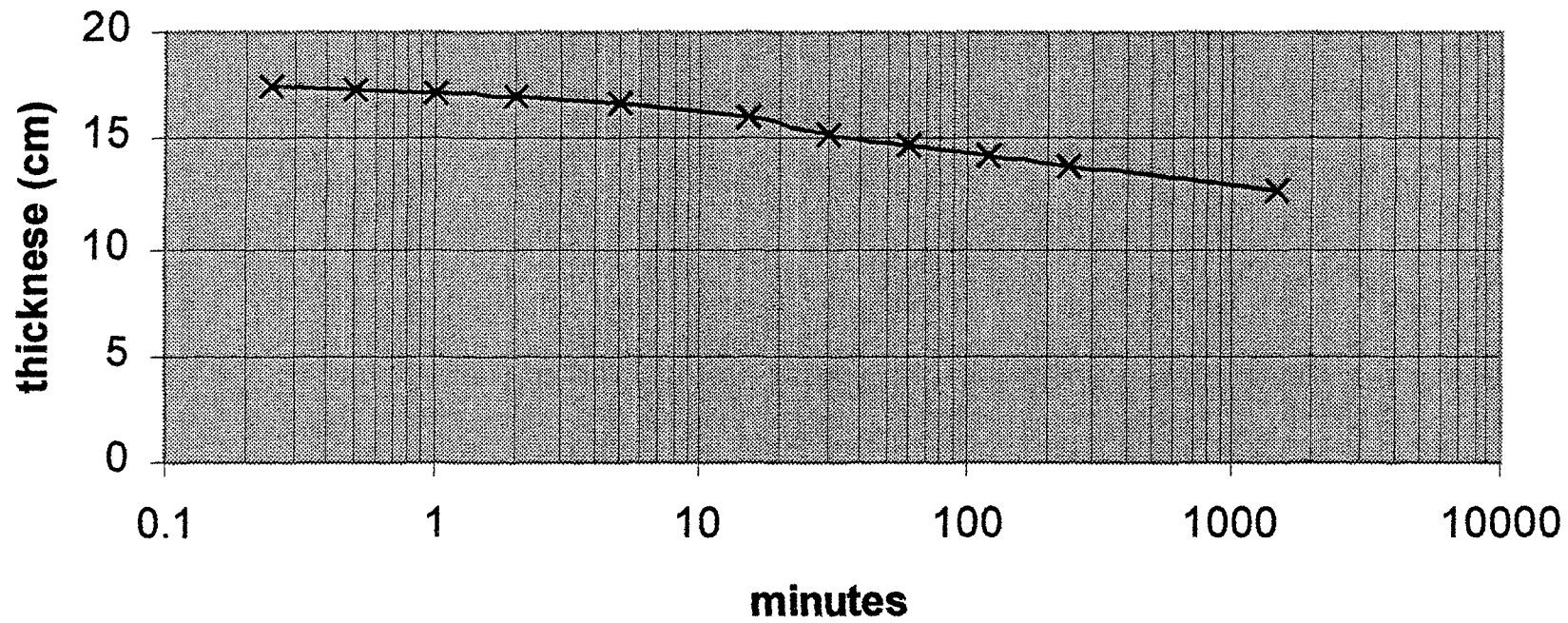
$$C_c = k \frac{(12.7 - 8.6)}{\log \left(\frac{4.91}{2.29} \right)}$$

$$= k \frac{4.1}{(0.313)}$$

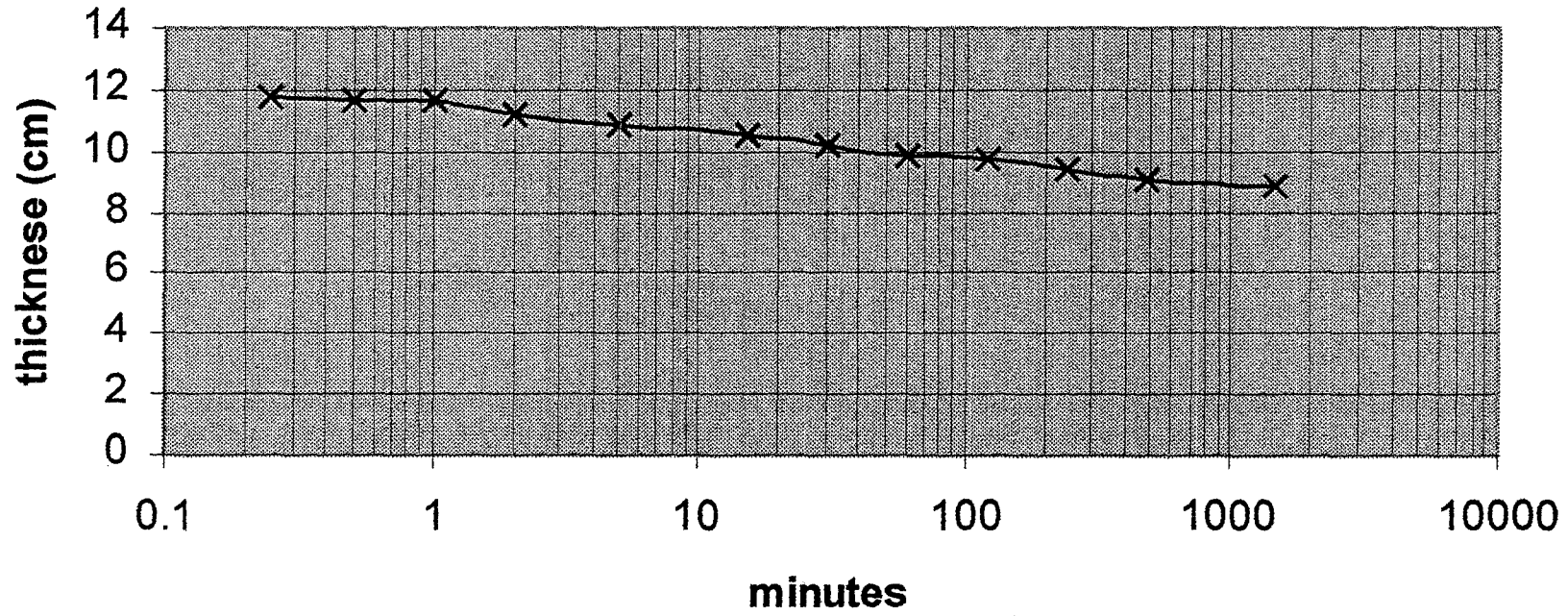
$$= 13.11 k \rightarrow 131.12 k \text{ cm}^3/\text{N}$$

Fig. 1 - Effective Stress-Settlement curve

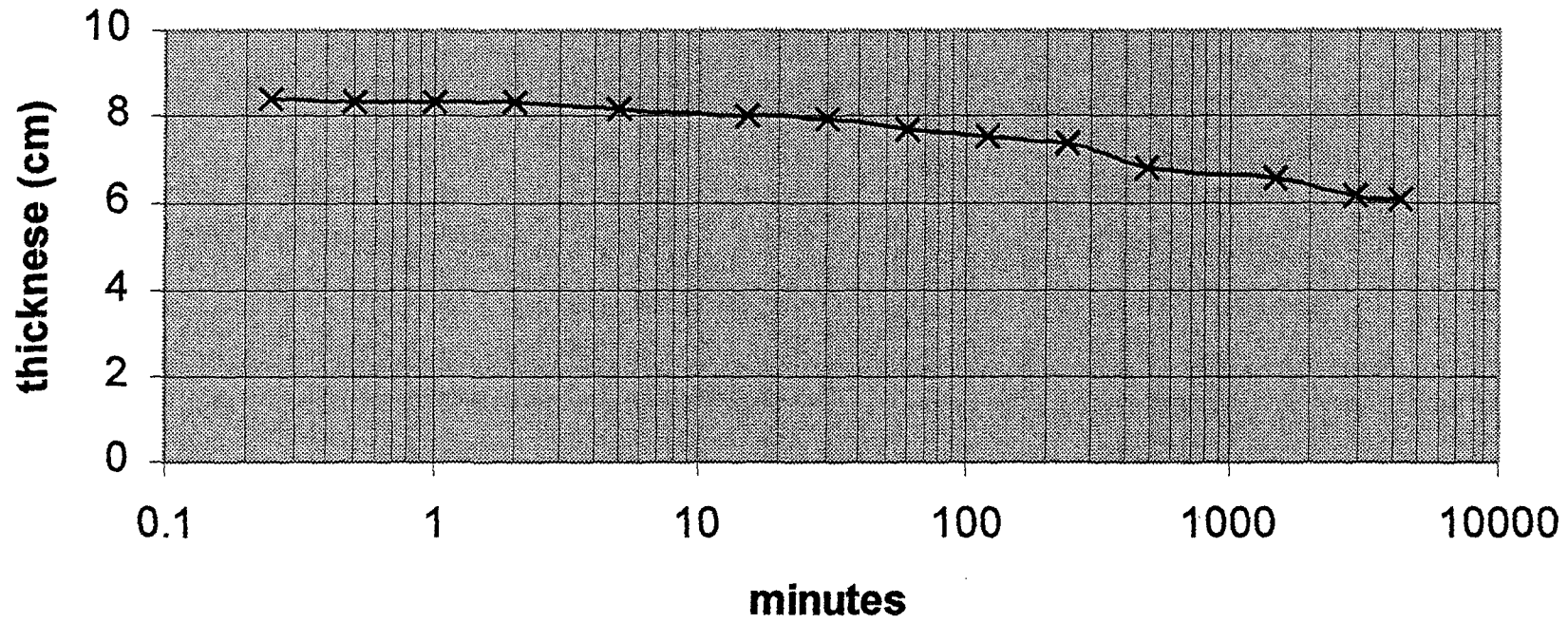
load increment from 1.37-2.39 kN/m²



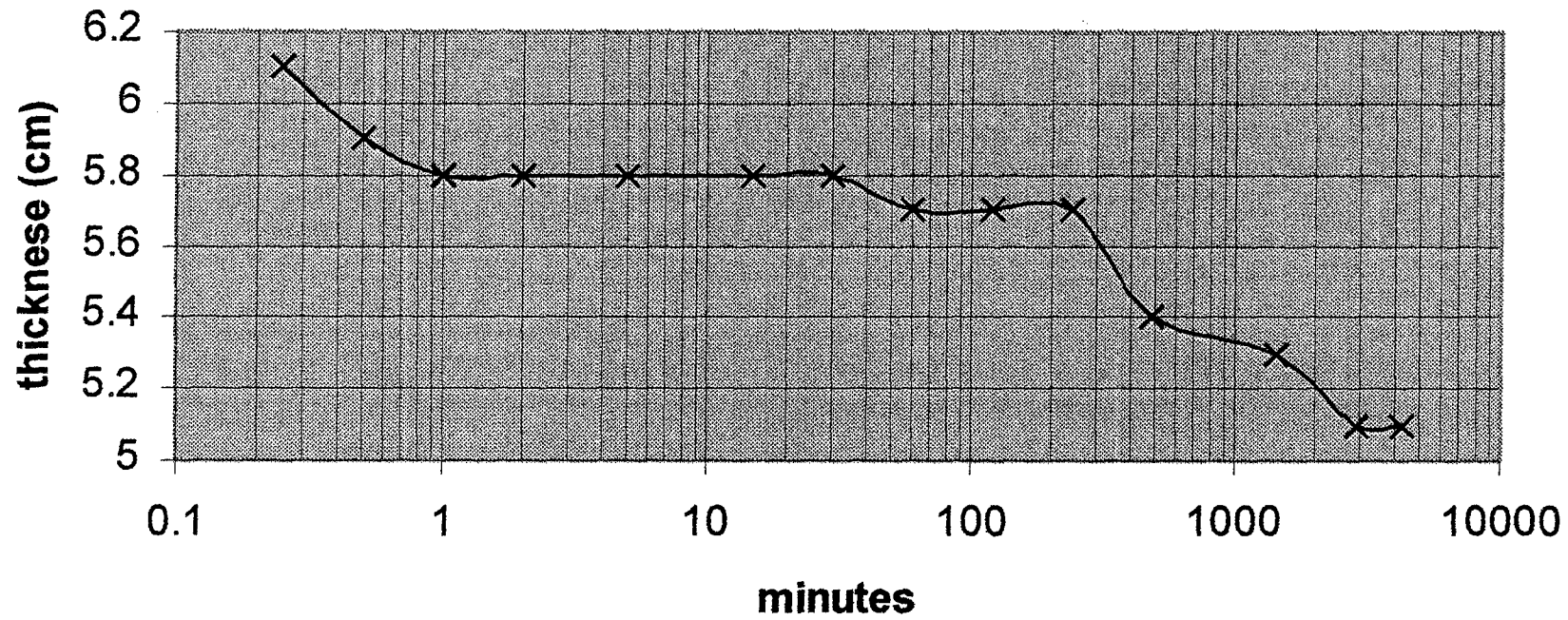
load increment from 2.39-4.91 kN/m²



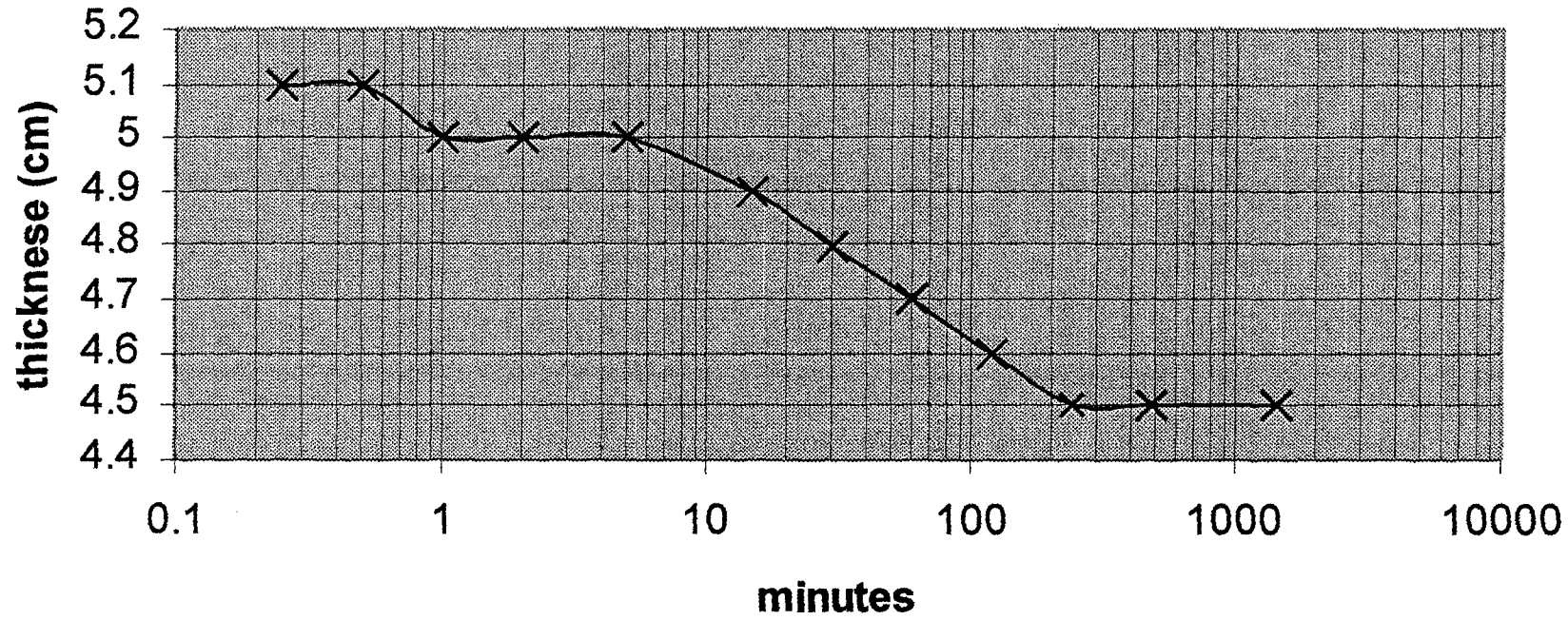
load increment from 4.91-9.95 kN/m²



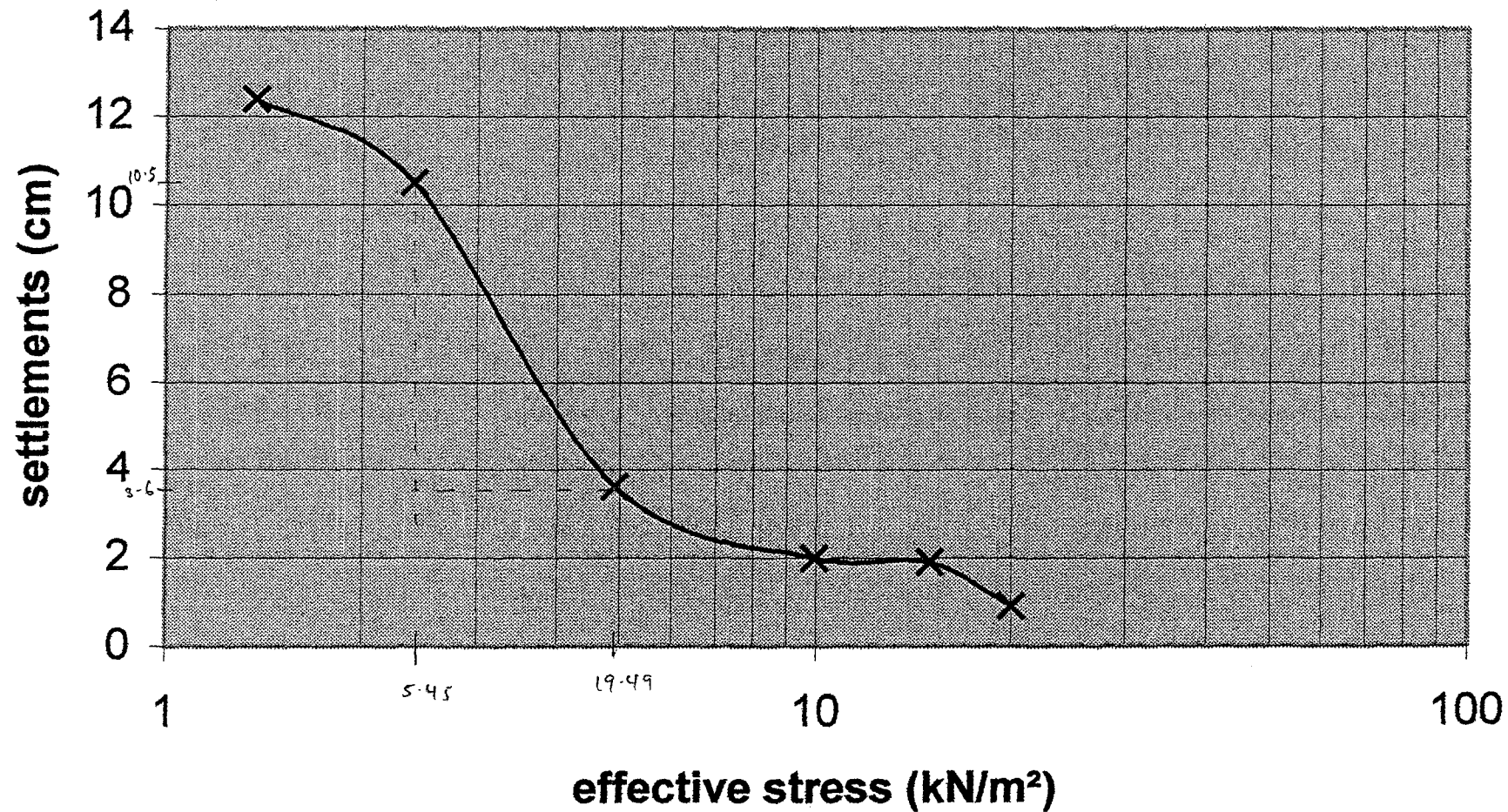
load increment from 9.95-14.99 kN/m²



load increment from 14.99-25.07 kN/m²



spinach and kangkung

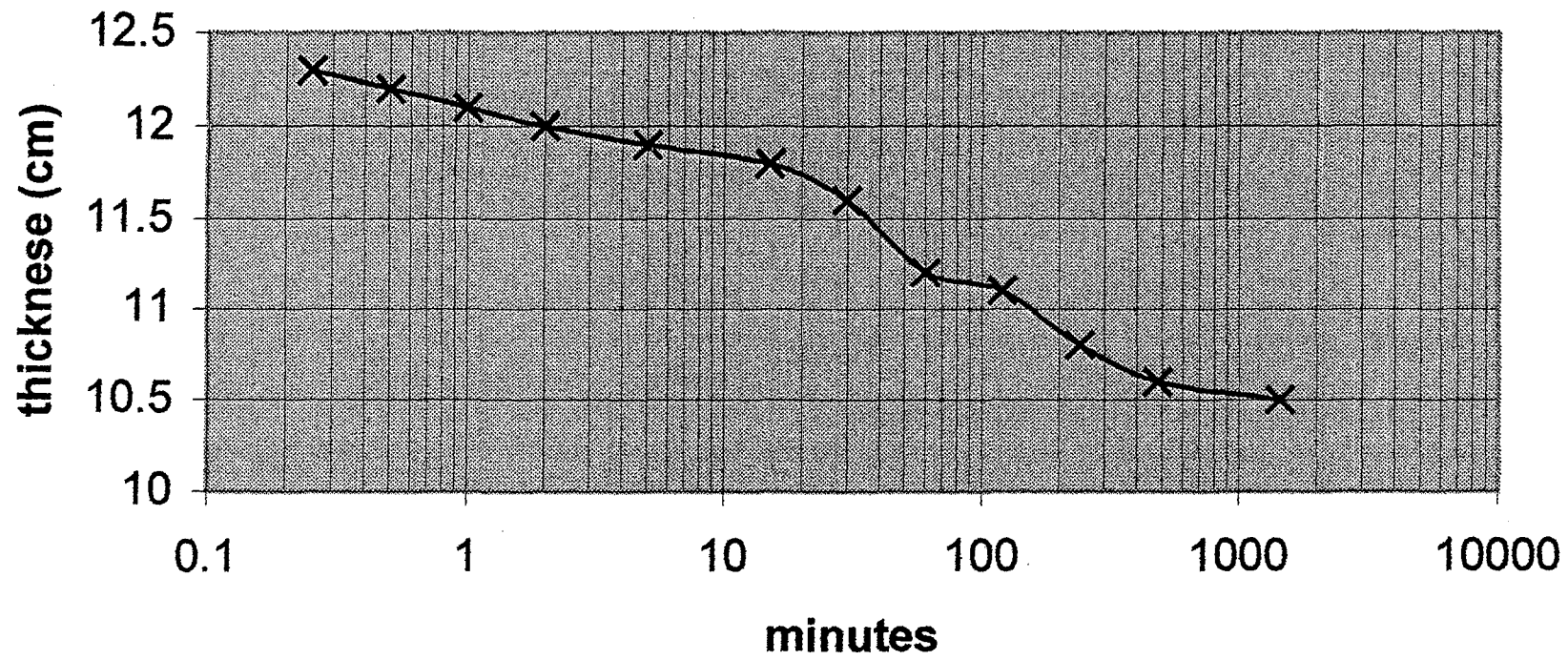


$$c_c = k \left(\frac{10.5 - 3.6}{\log \left(\frac{19.49}{5.45} \right)} \right)$$

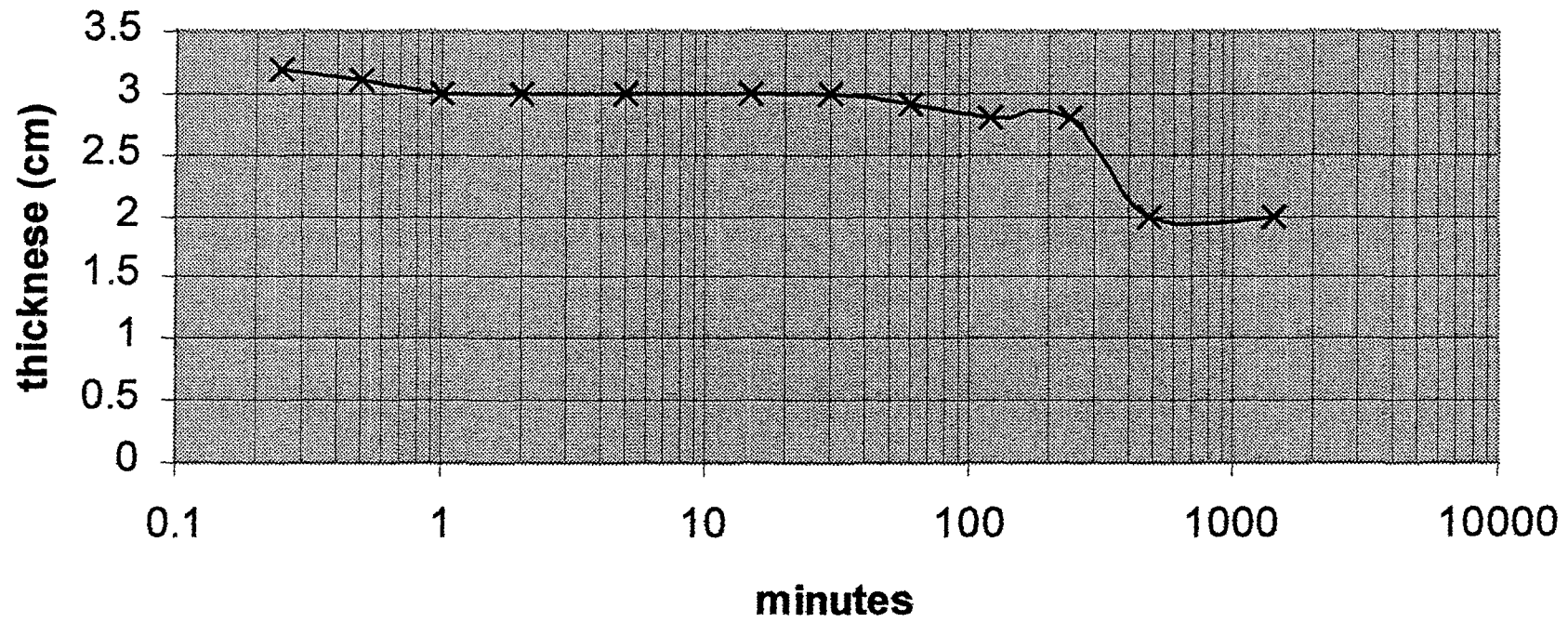
$$= k \frac{6.9}{0.553} = 12.46 k \rightarrow \underline{124.68 \text{ k cm}^3/\text{N}}$$

Q = k (\Delta thickness)

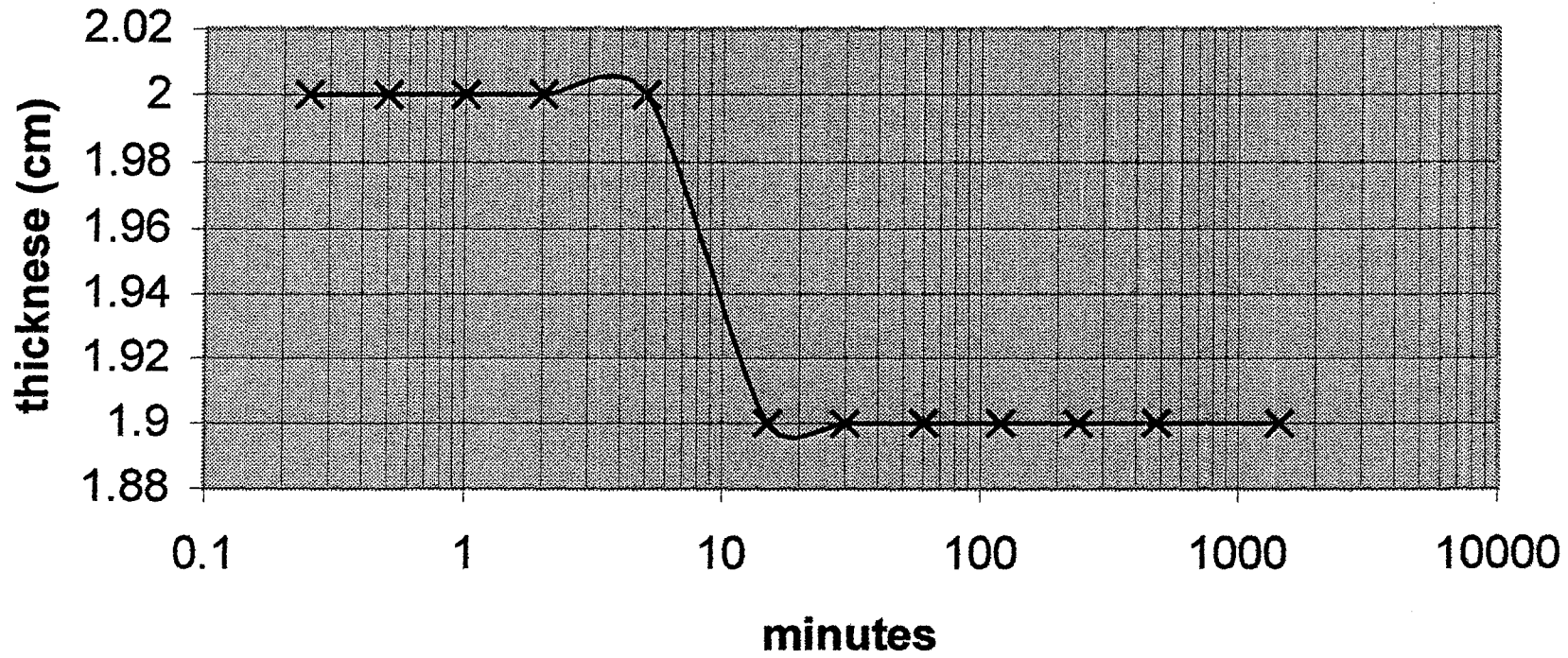
load increment from 1.39-2.39 kN/m²



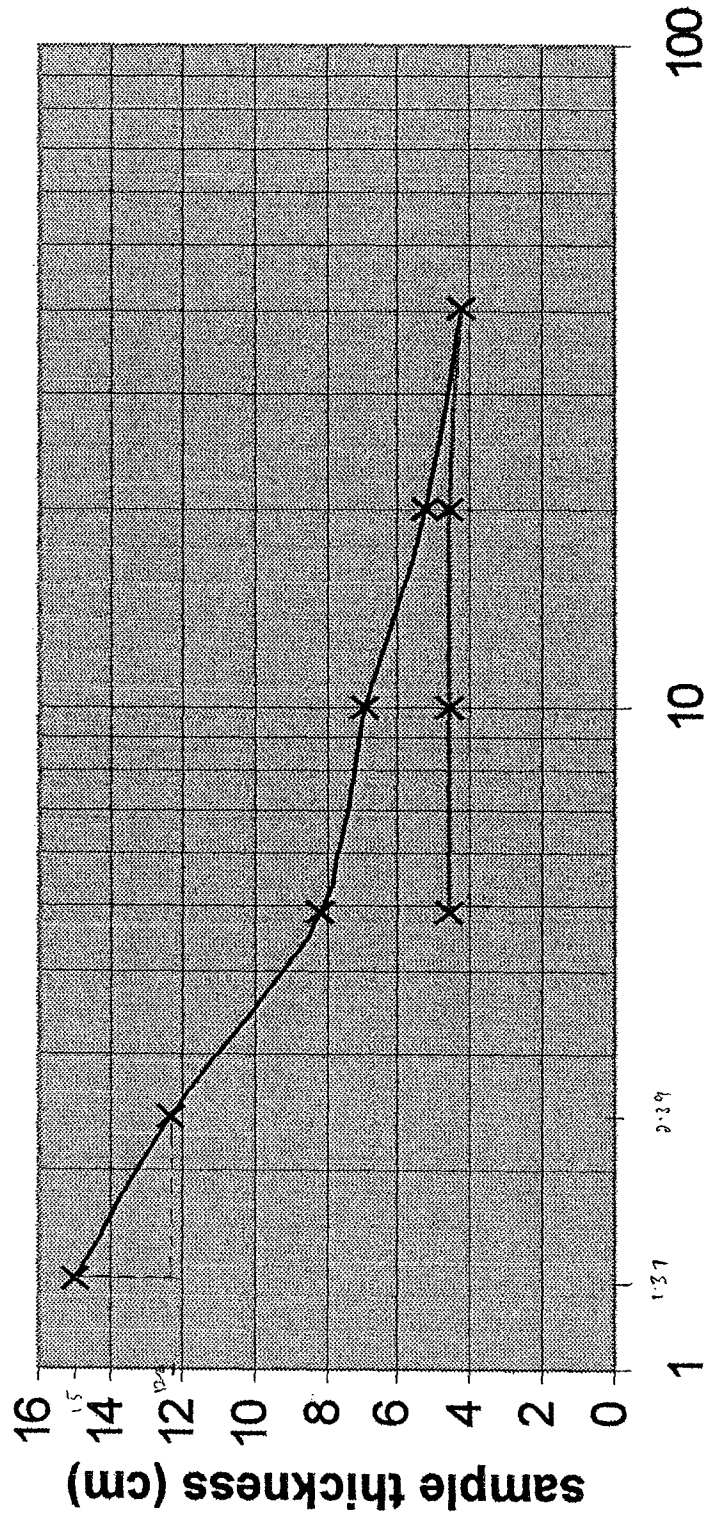
load increment from 4.91-9.95 kN/m²



load increment from 9.95-14.99 kN/m²



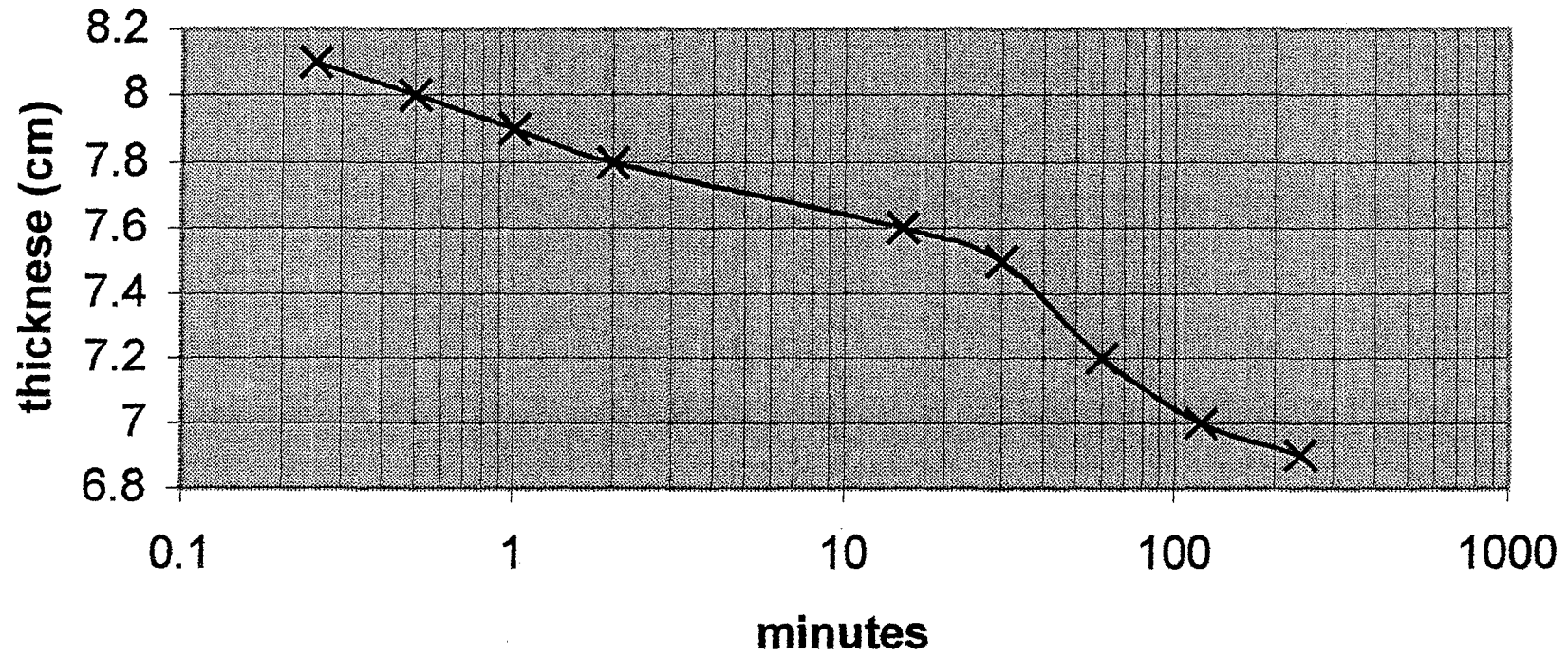
fishes (whole)



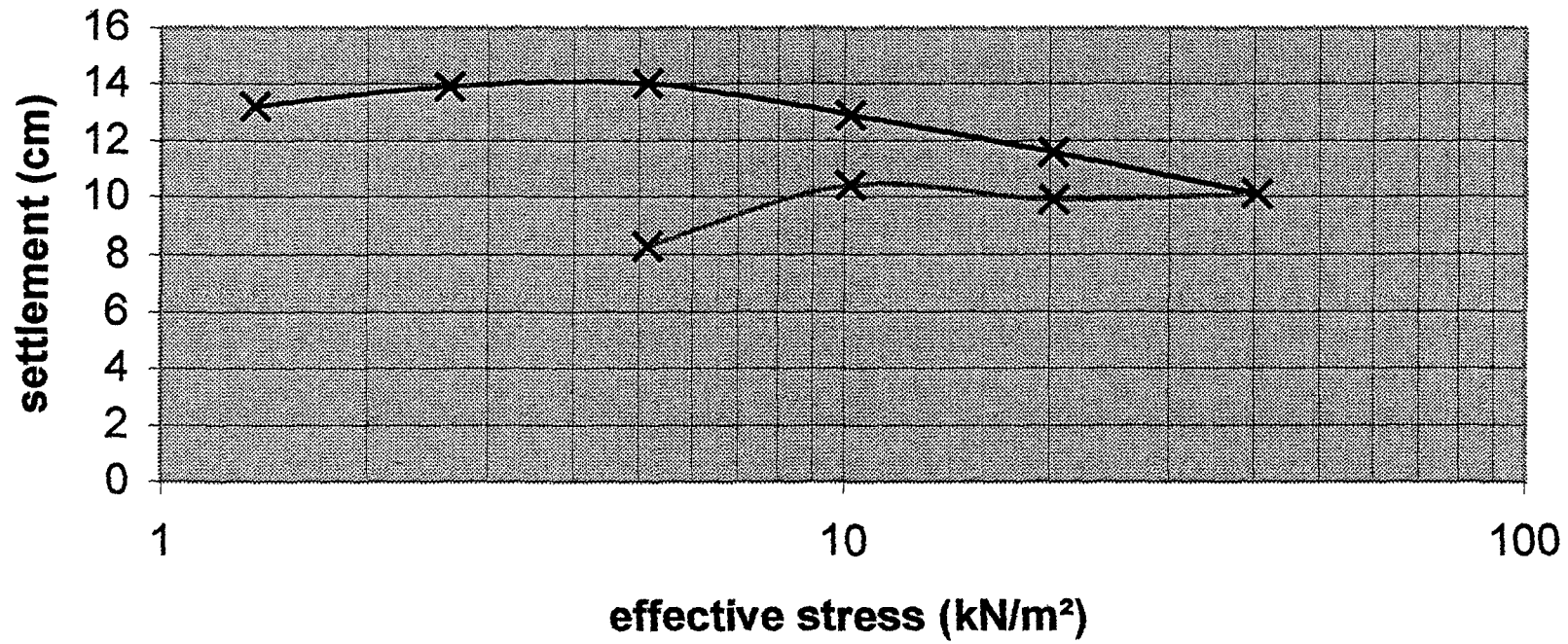
$$C_c = k \left(\frac{\Delta c}{\Delta \sigma'} \right)$$

$$\begin{aligned}
 C_c &= k \left(\frac{15 - 12.2}{2.89} \right) \\
 &= k \left(\frac{2.8}{0.242} \right) \\
 &= 11.57 k \text{ cm}^3/\text{N}
 \end{aligned}$$

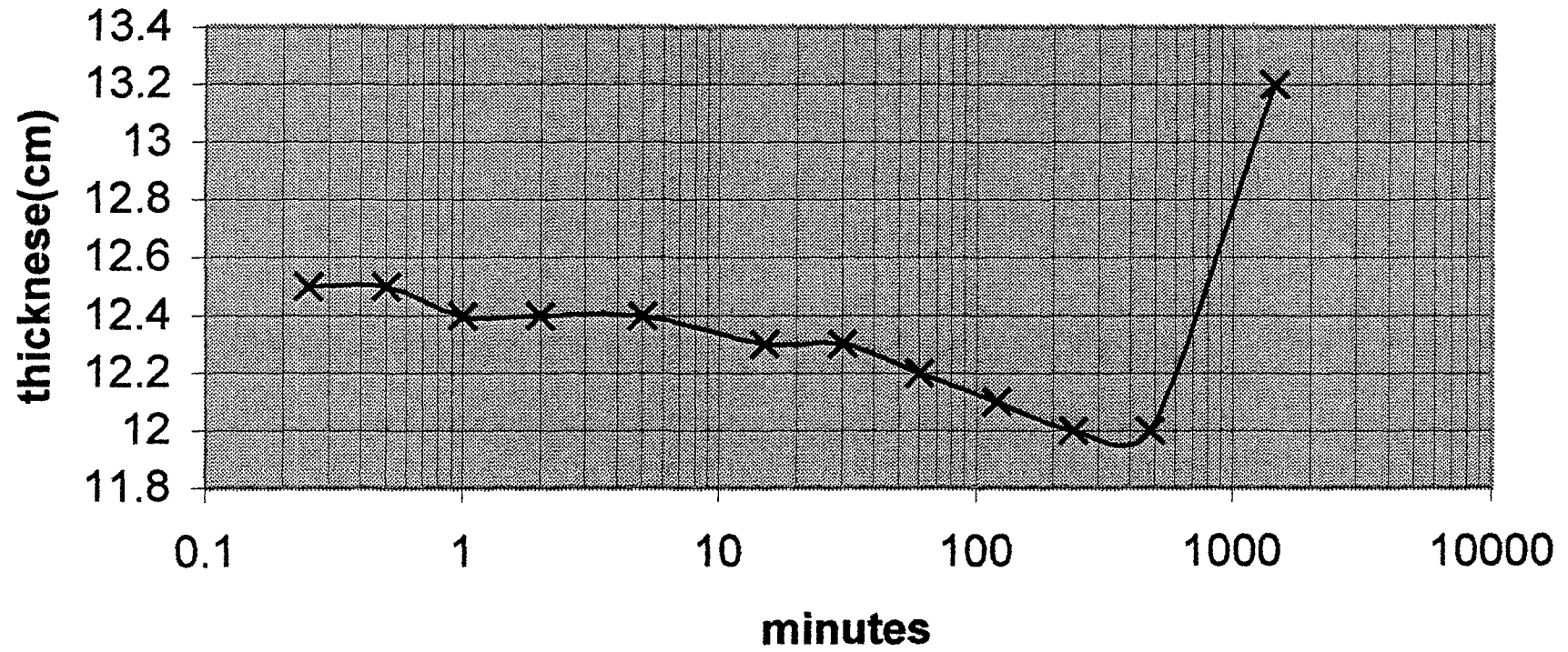
load increment from 4.91-9.95 kN/m²



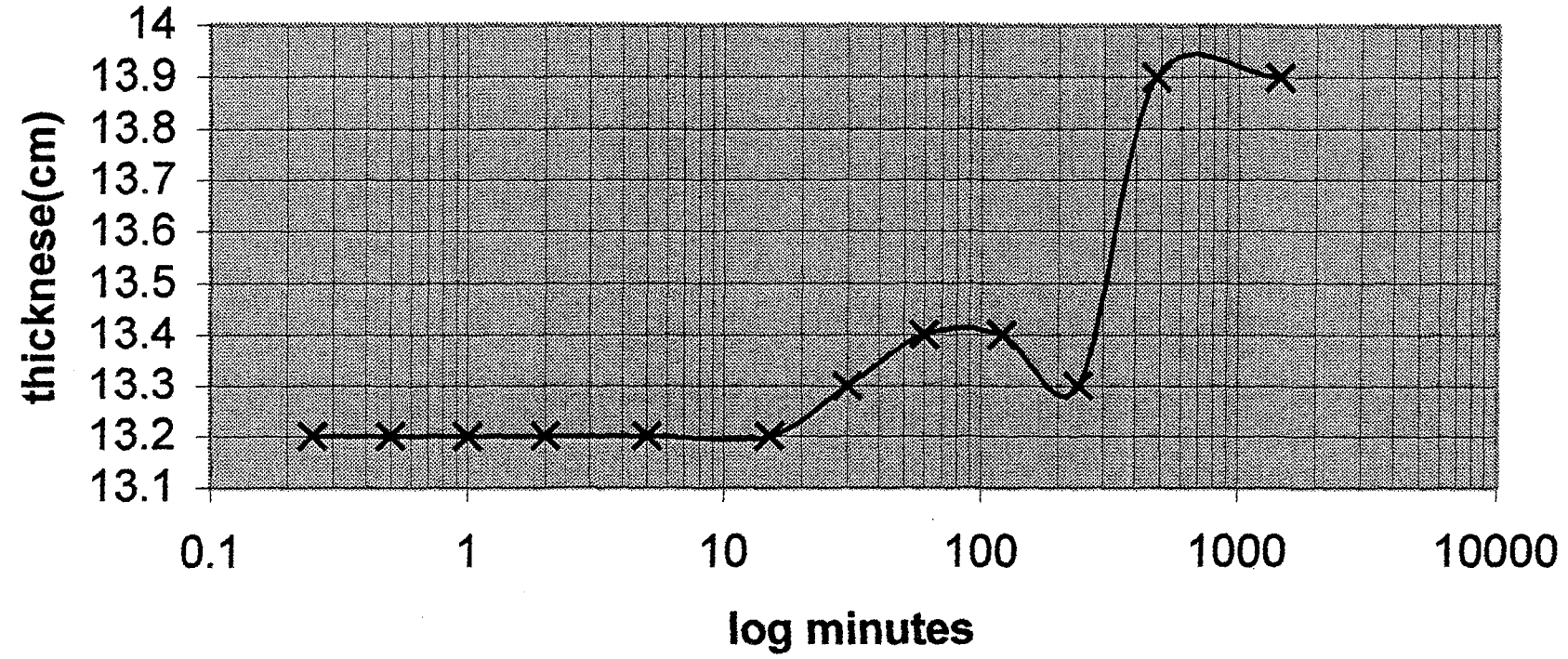
fresh meat



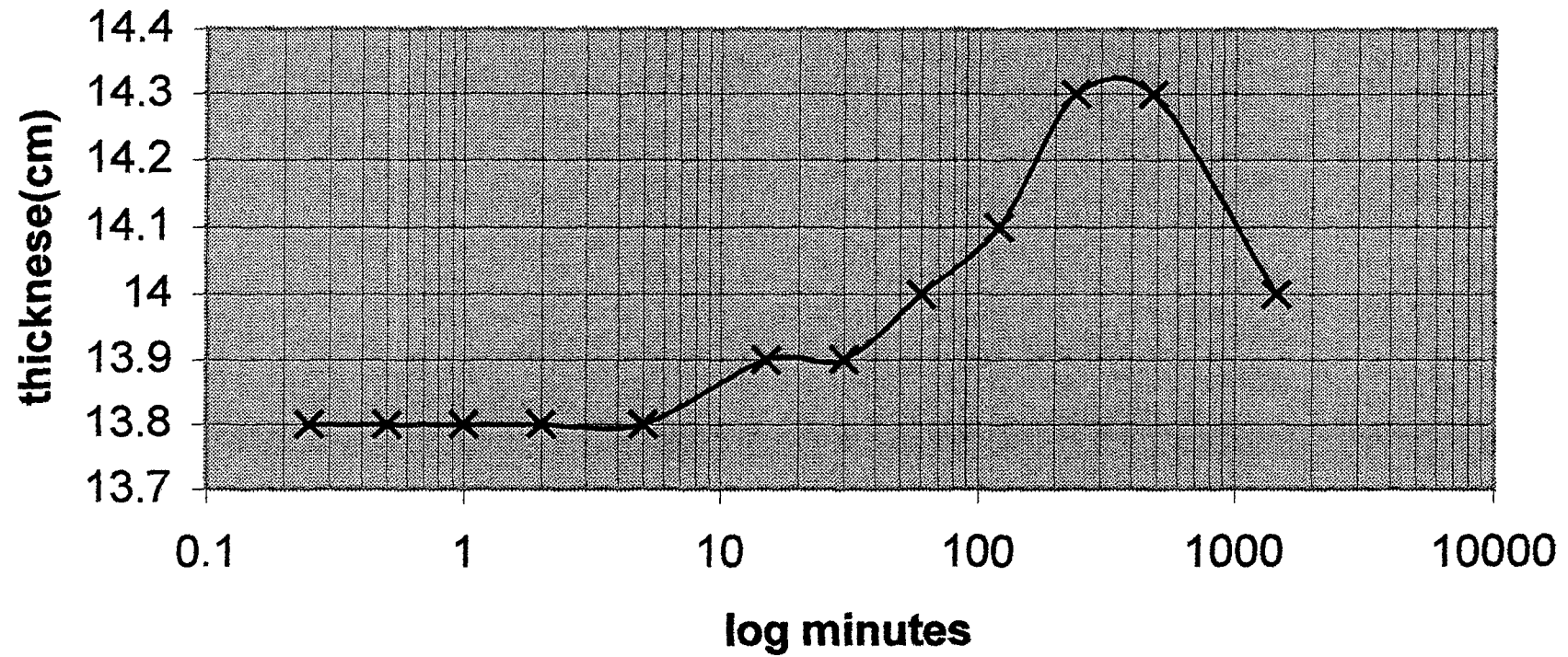
Load acting at 1.37kN/m²



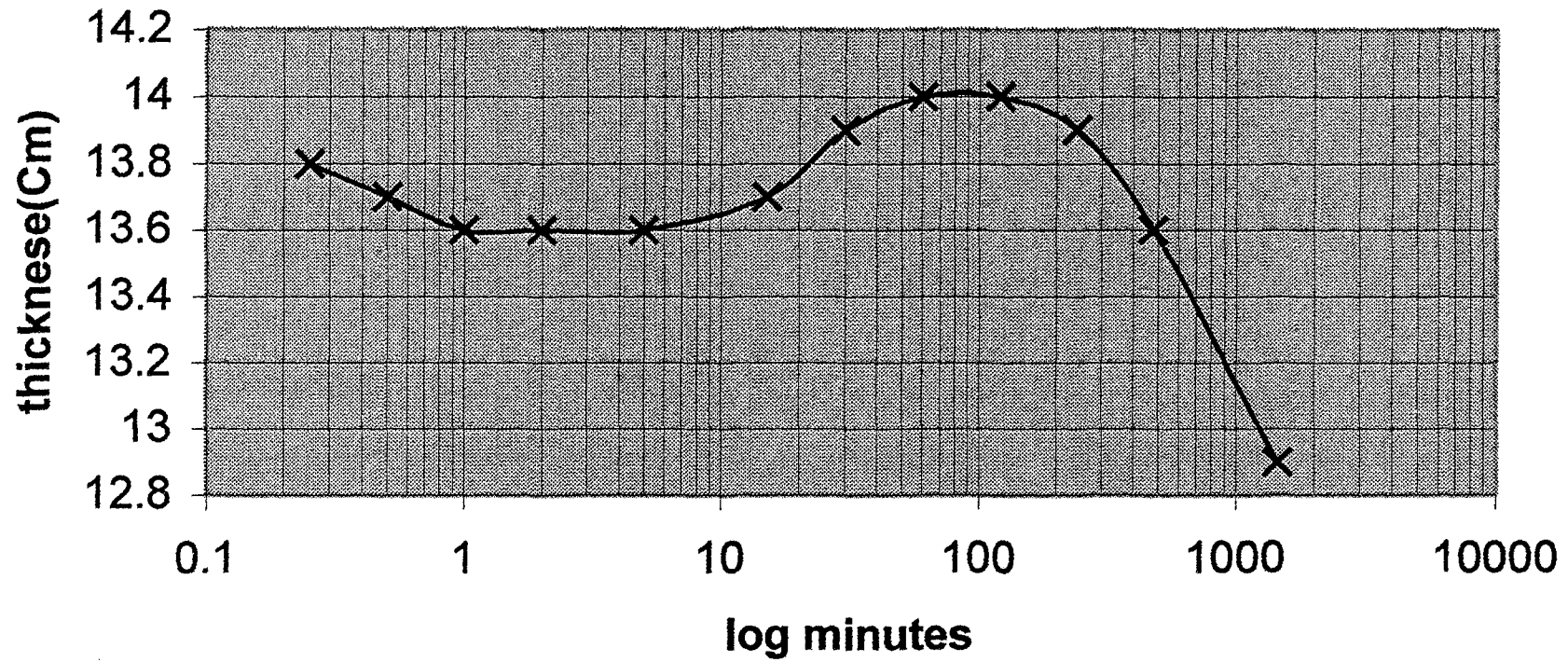
load increment from 1.37-2.63 kN/m²



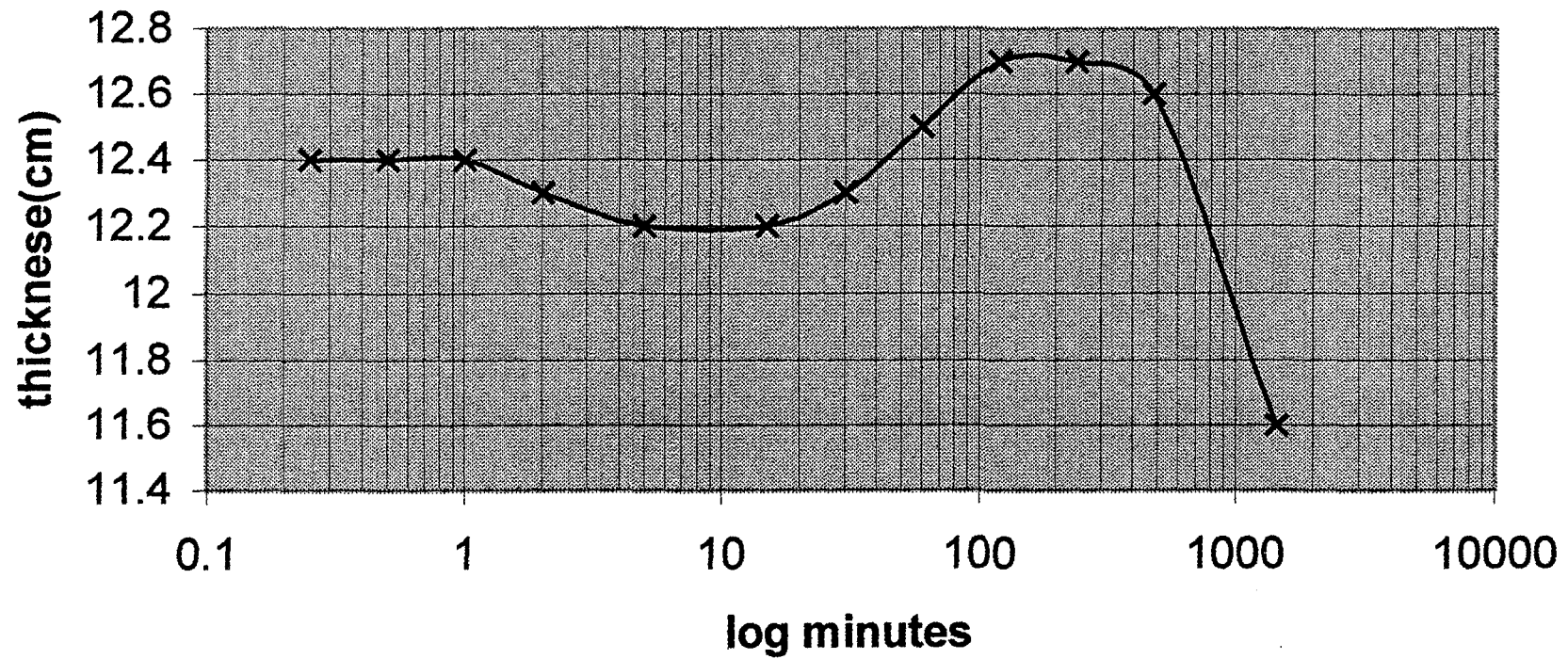
load increment from 2.63-5.14kN/m²



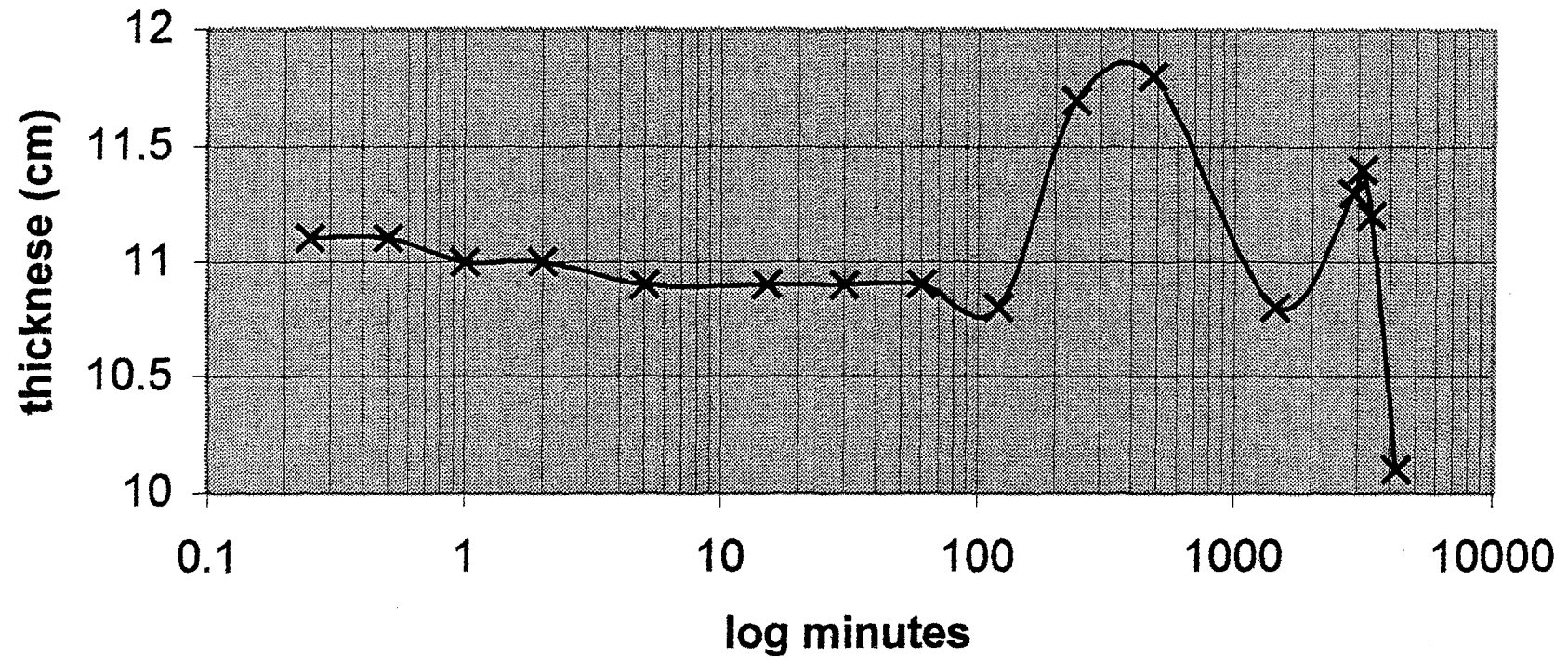
Load increment from 5.14-10.23 kN/m²



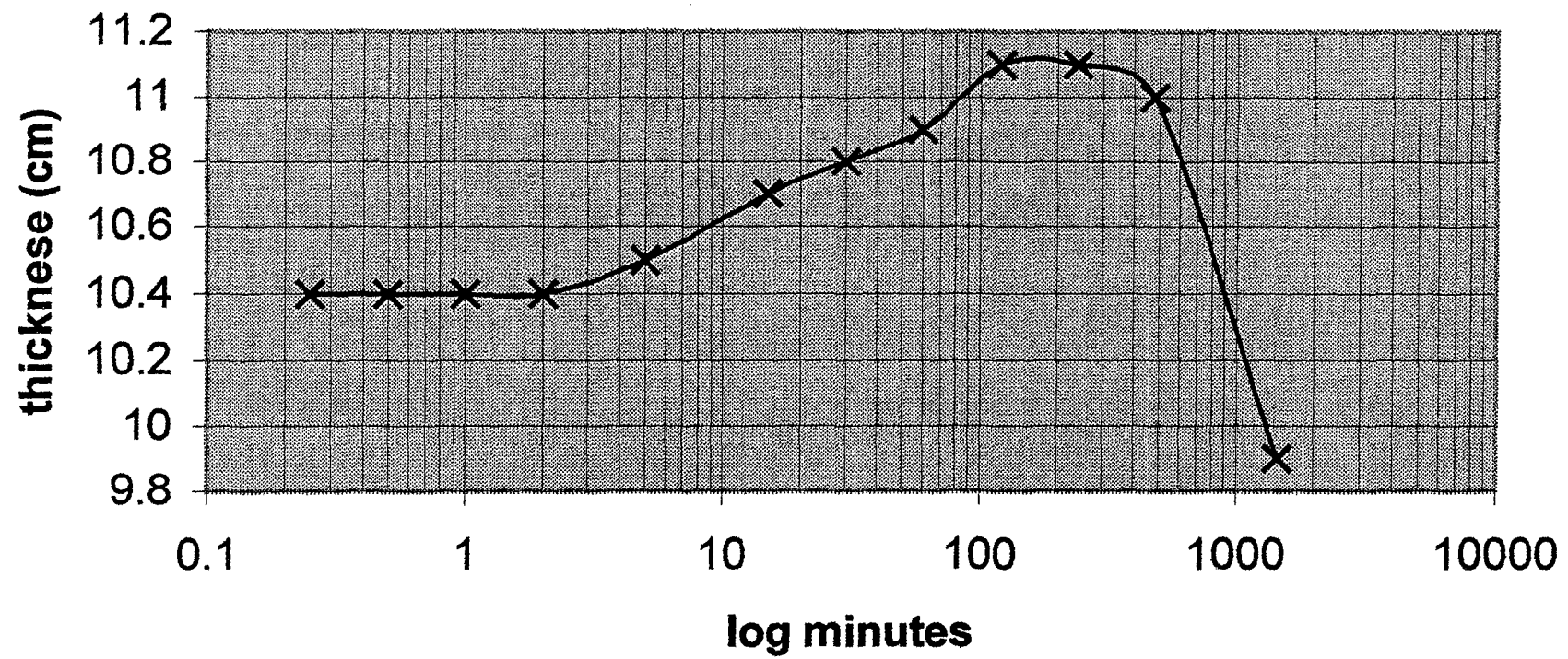
Load increment from 10.23-20.32 kN/m²



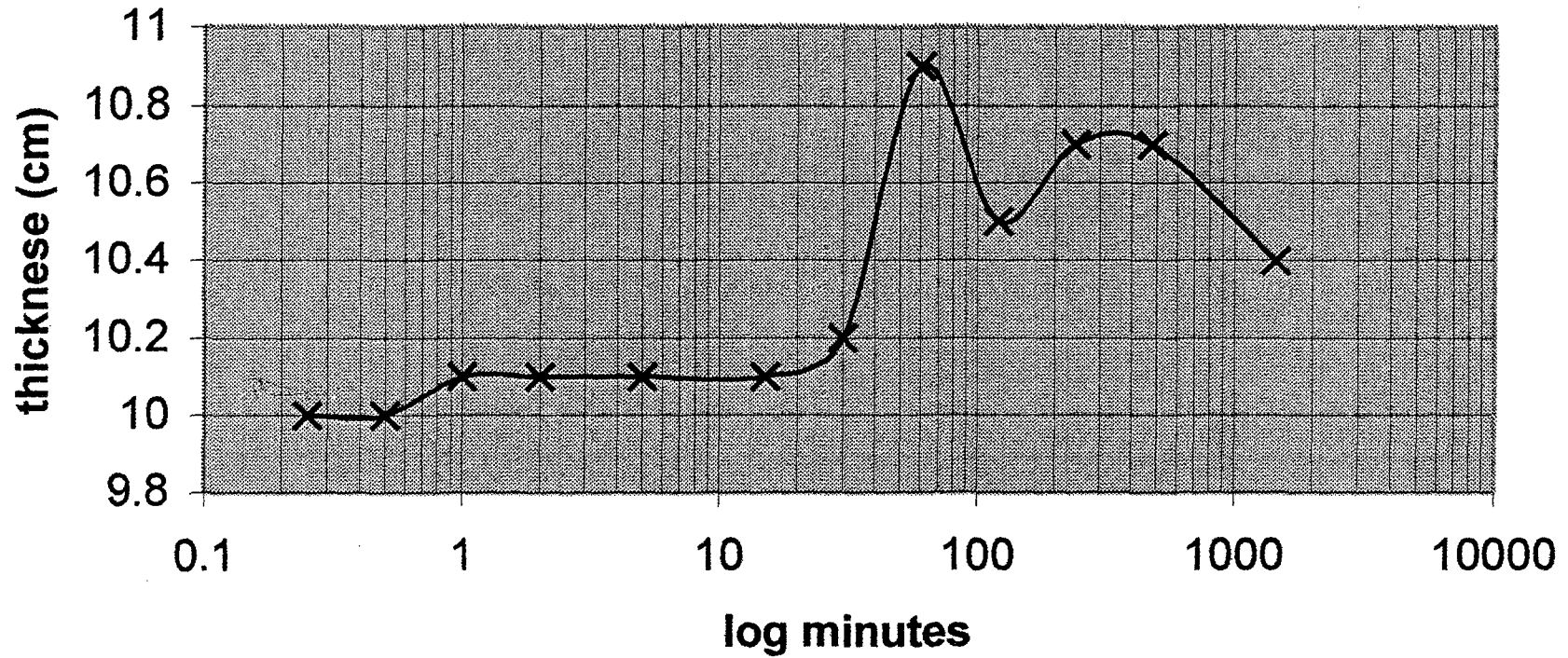
load increment from 20.32-40.44 kN/m²



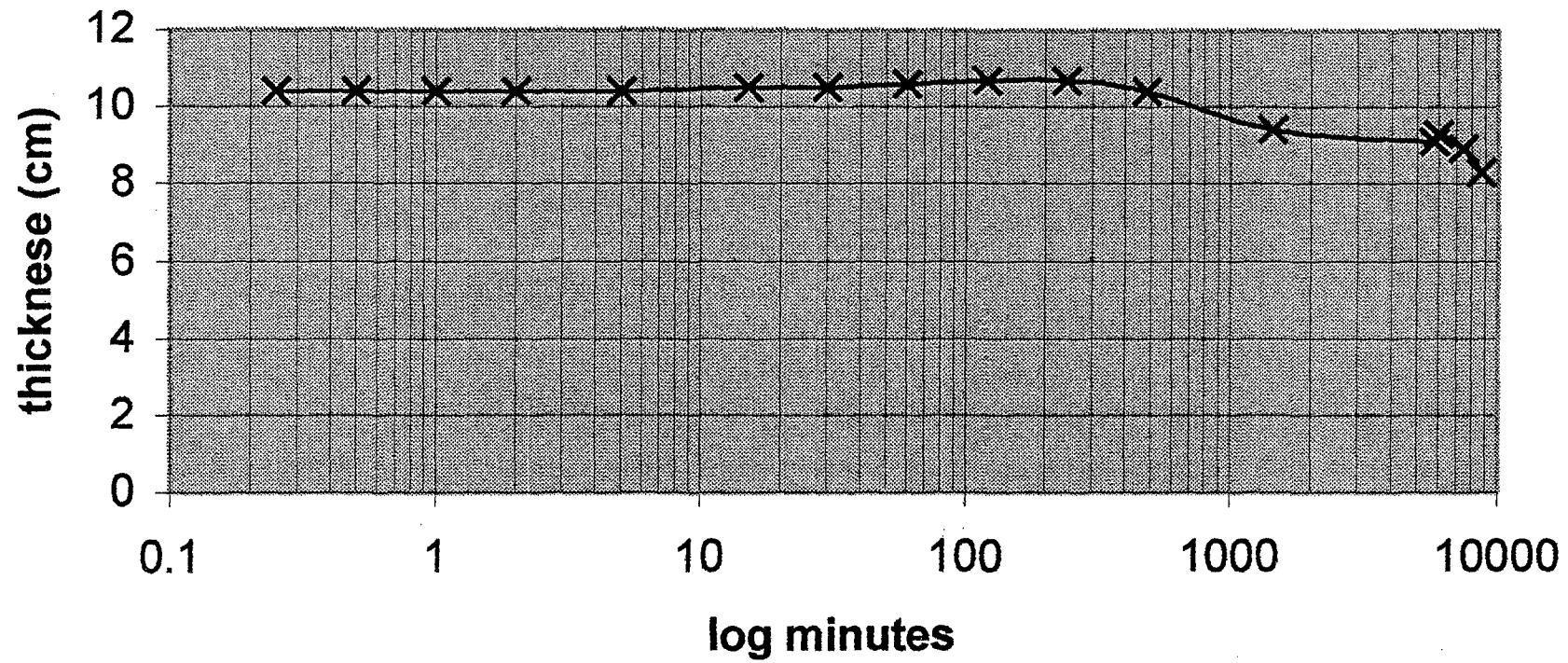
load reducing from 40.44-20.32 kN/m²



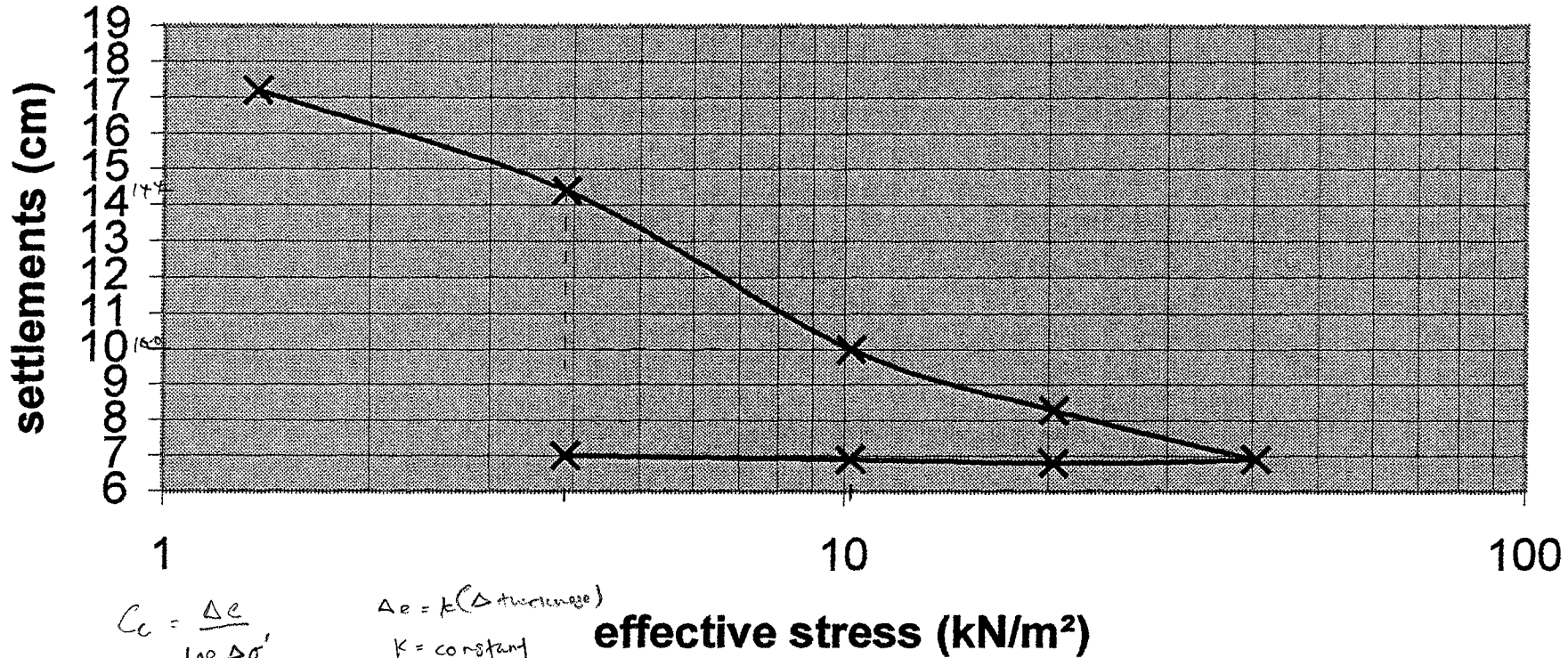
load reducing from 20.32-10.23 kN/m²



load reducing from 10.23-5.14 kN/m²



news paper



$$C_c = \frac{\Delta e}{\log \Delta \sigma'}$$

$$\Delta e = k(\Delta \log \sigma')$$

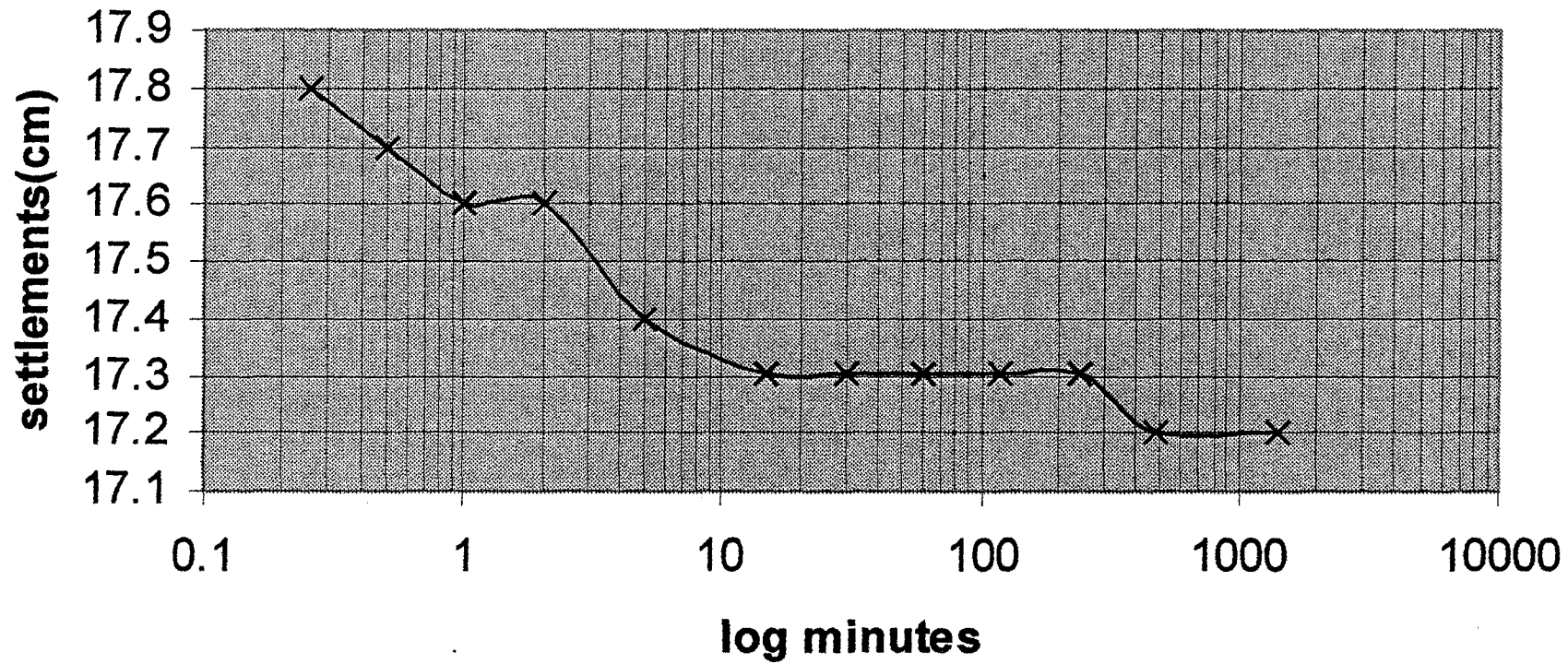
$k = \text{constant}$

$$= k \frac{(14.4 - 10.0)}{\log \left(\frac{10.24}{1.44} \right)}$$

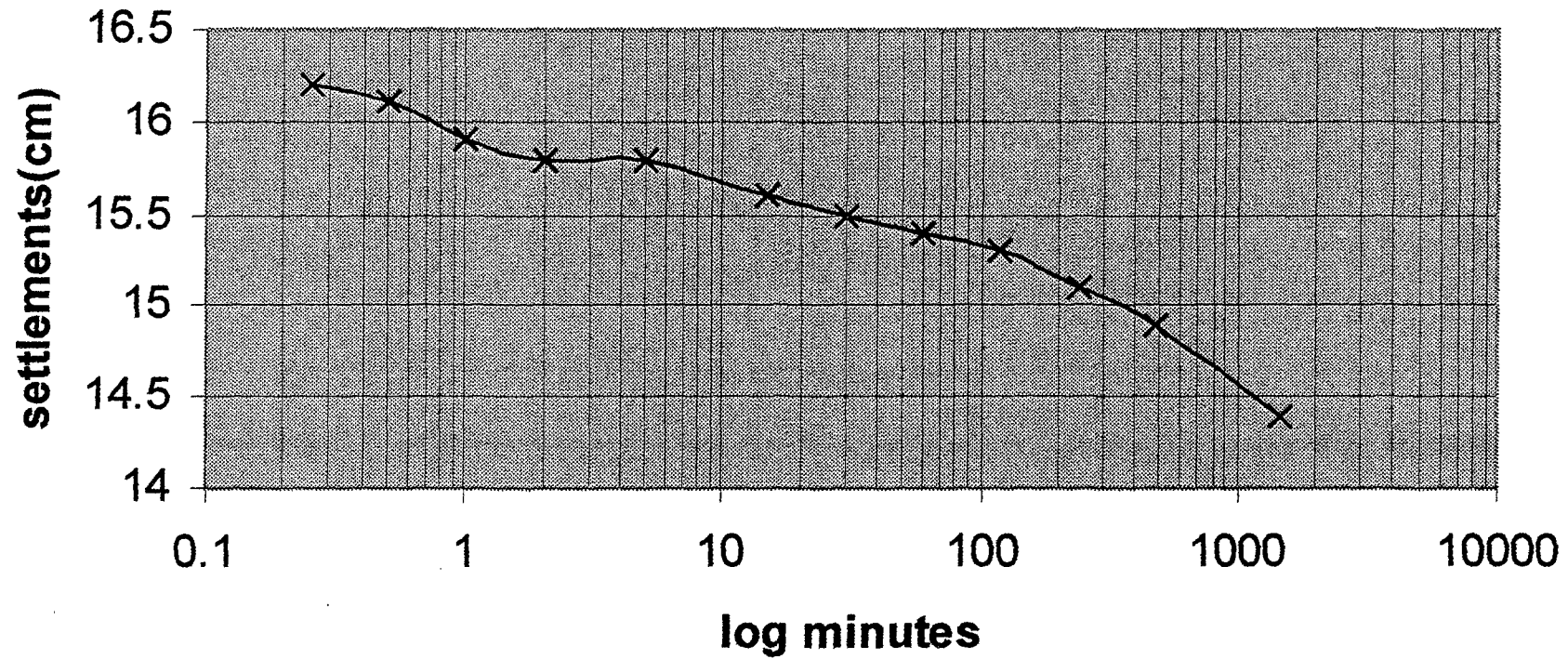
$$= k \left(\frac{4.4}{0.42} \right)$$

$$C_c = 10.48 k \quad \frac{\text{cm}^3}{\text{N}}$$

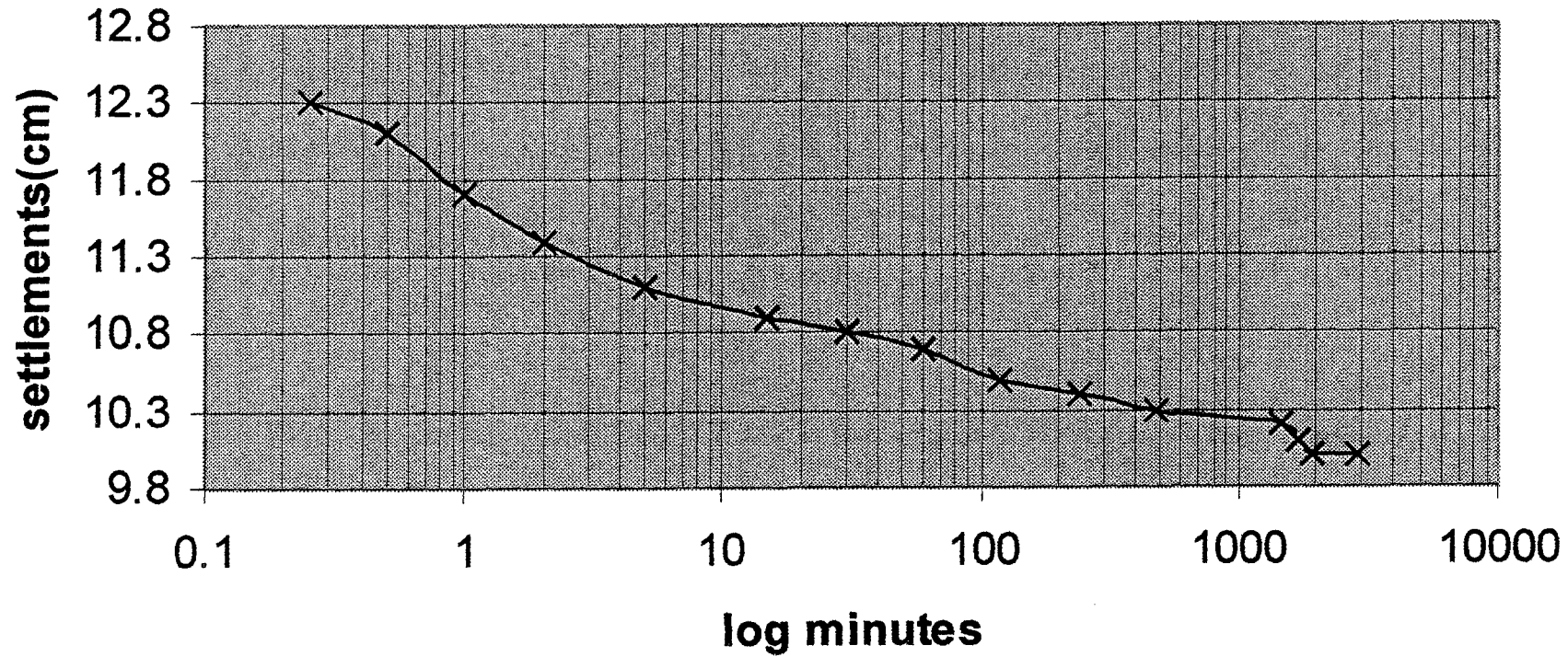
load acting at 1.37kN/m²



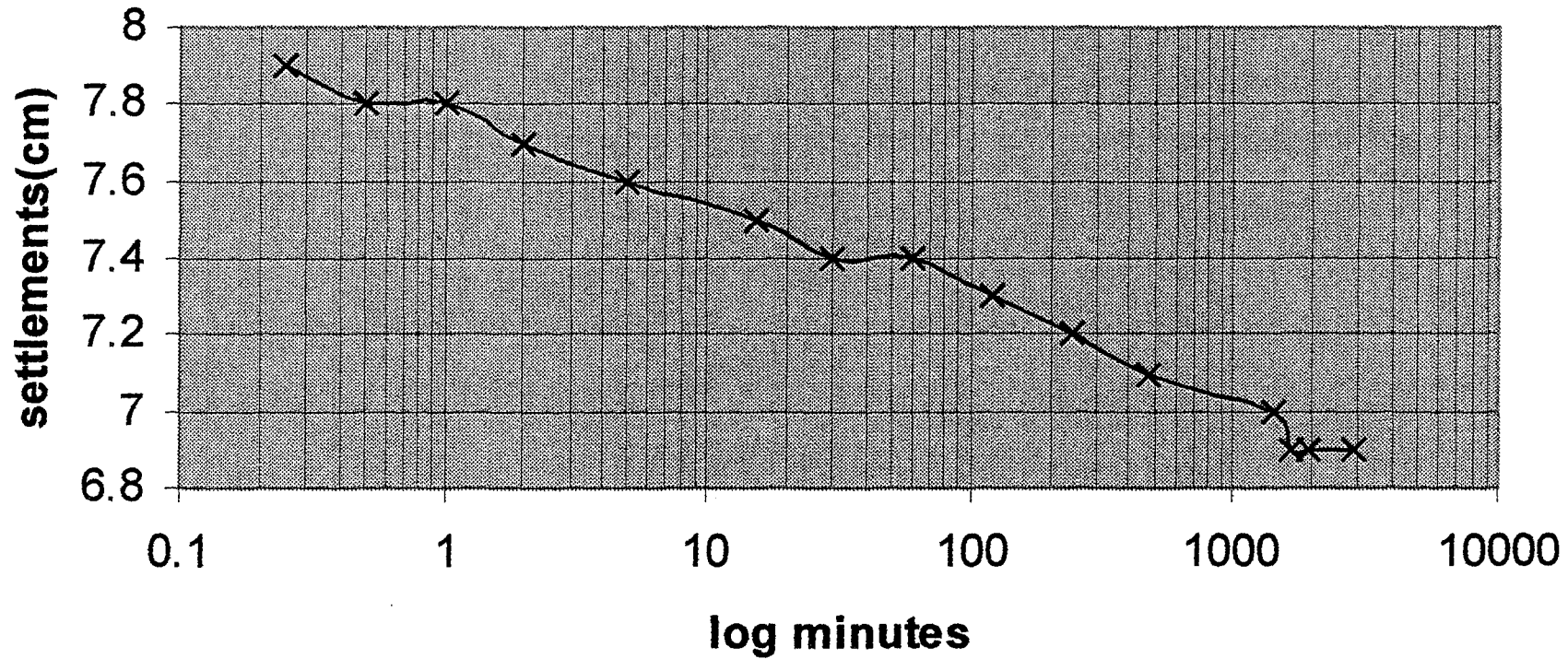
load increment from 1.37-3.89kN/m²



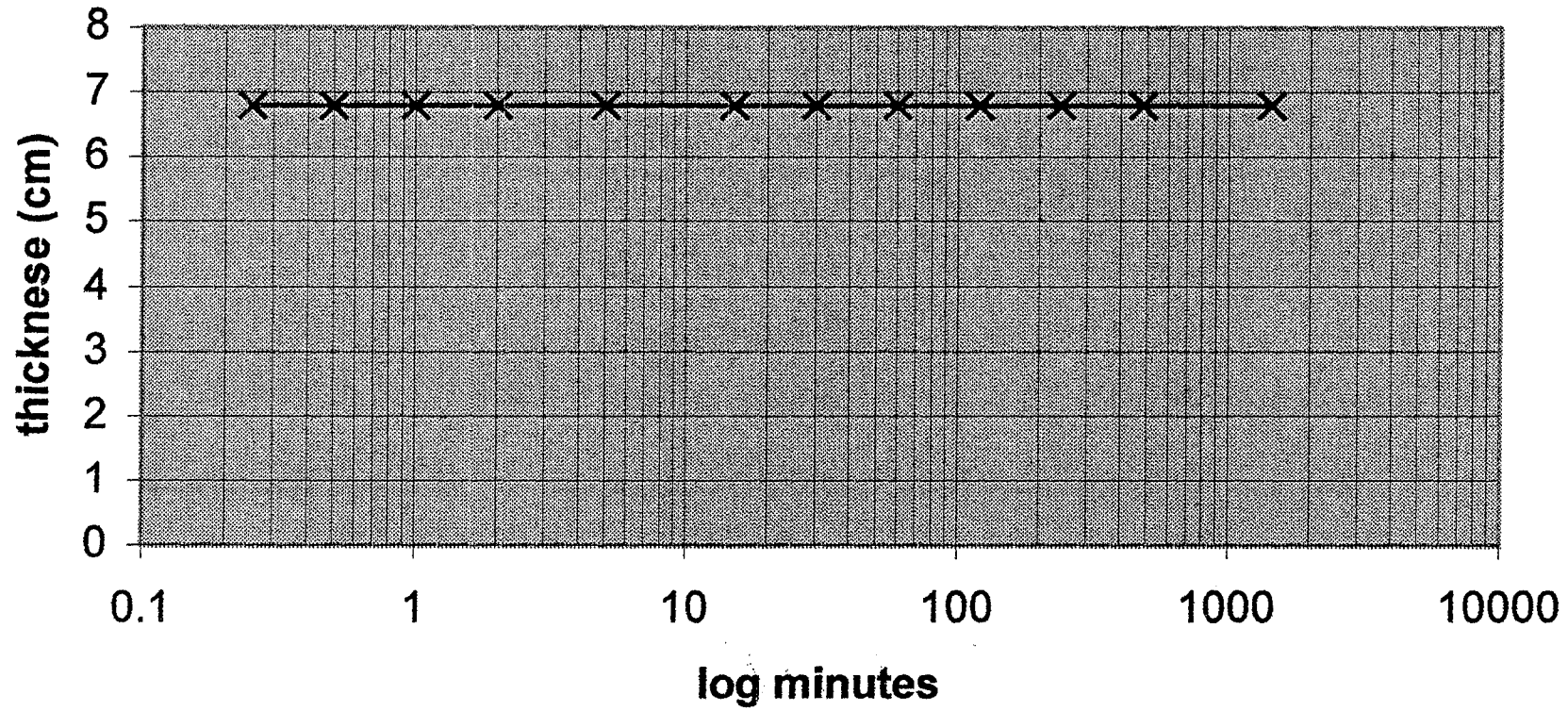
load increment from 3.89-10.24kN/m²



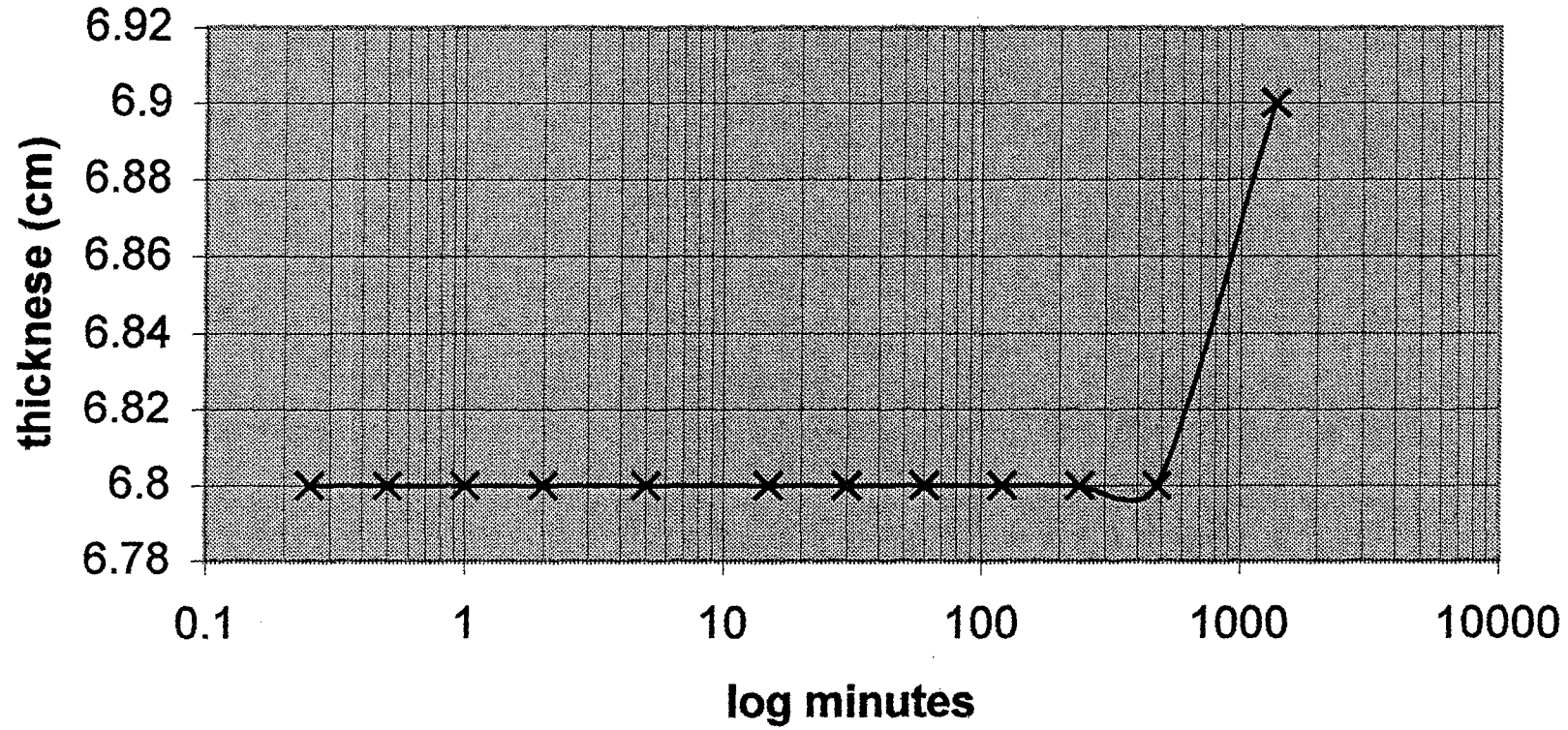
load increment from 20.34-40.46kN/m²



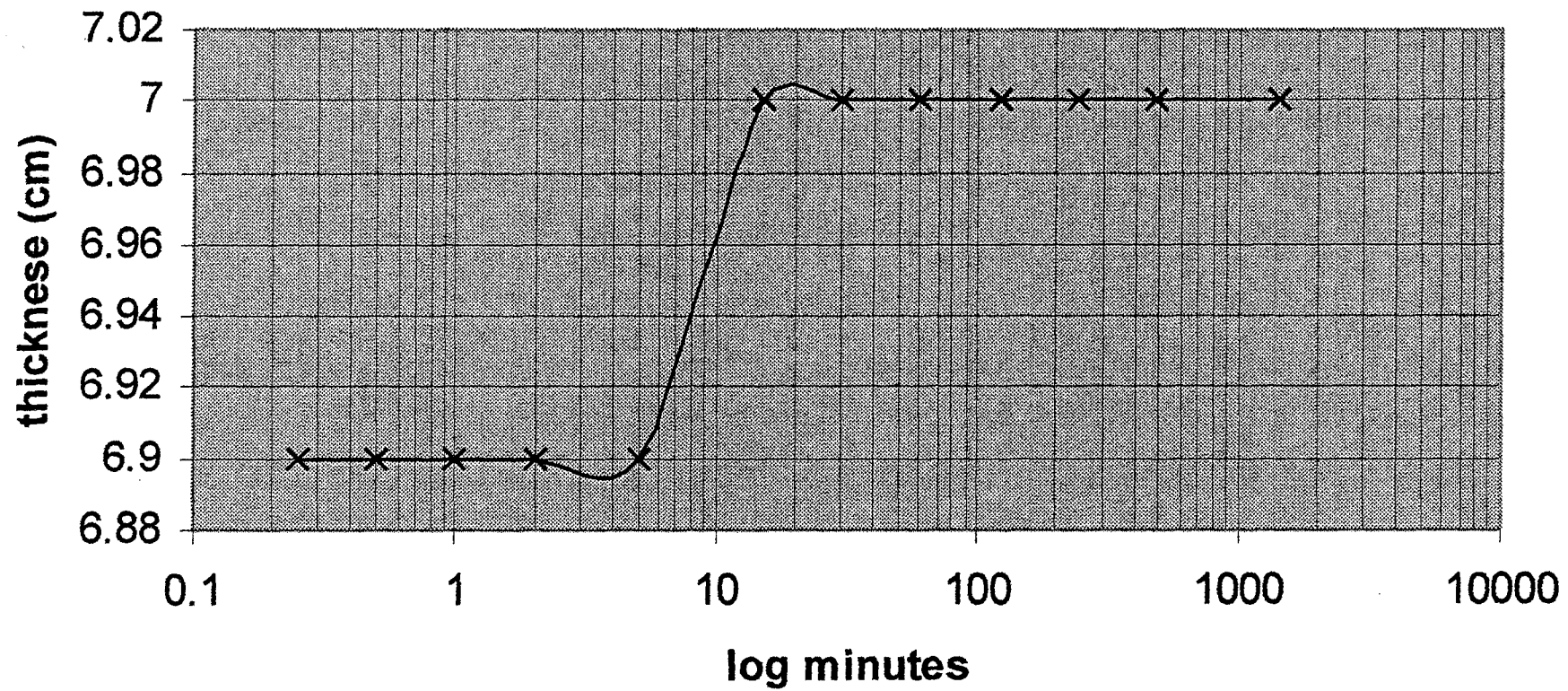
load reducing from 40.46-20.34 kN/m²



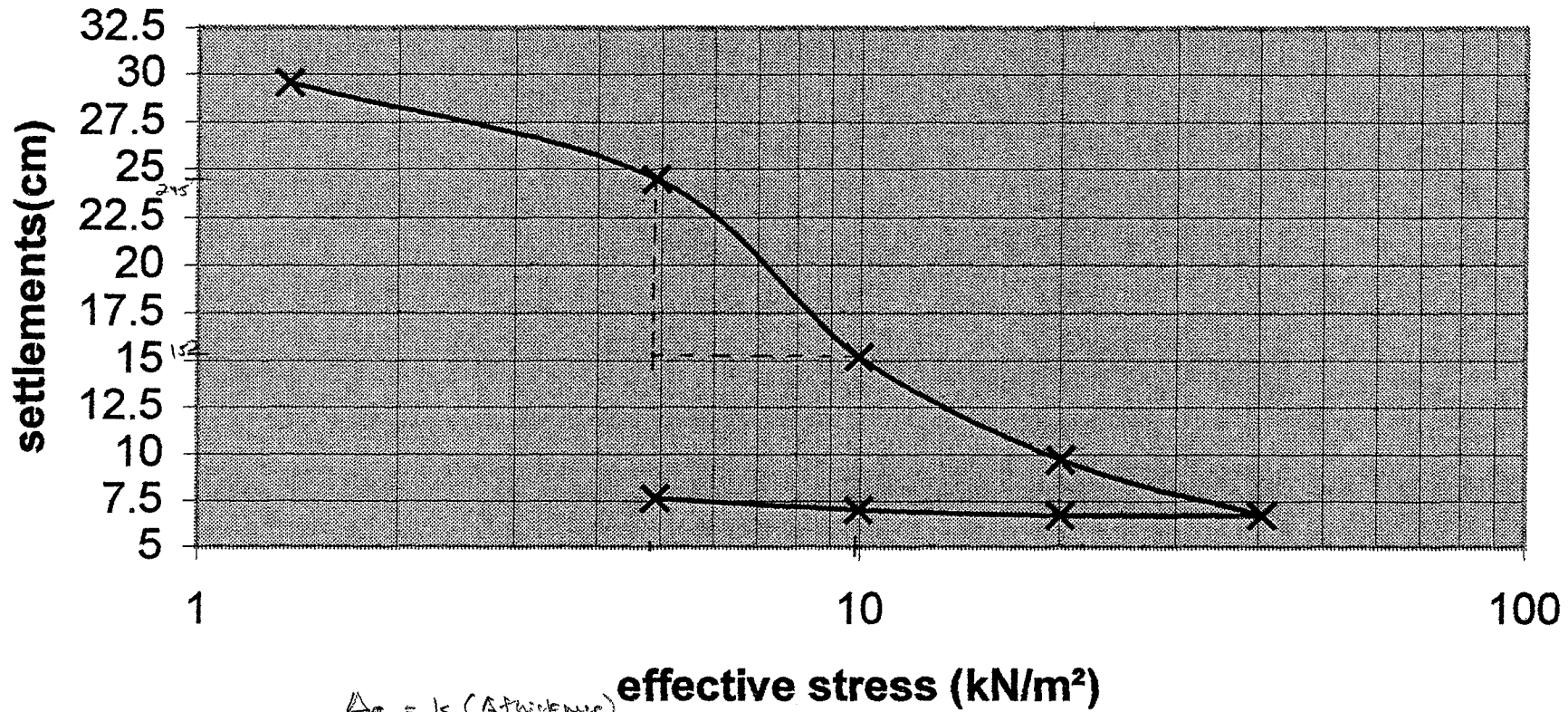
load reducing from 20.34-10.23 kN/m²



load reducing from 10.23-5.14 kN/m²



Plastics



$$C_c = \frac{\Delta e}{\Delta \sigma'}$$

$$\Delta e = k (\Delta \sigma')^n$$

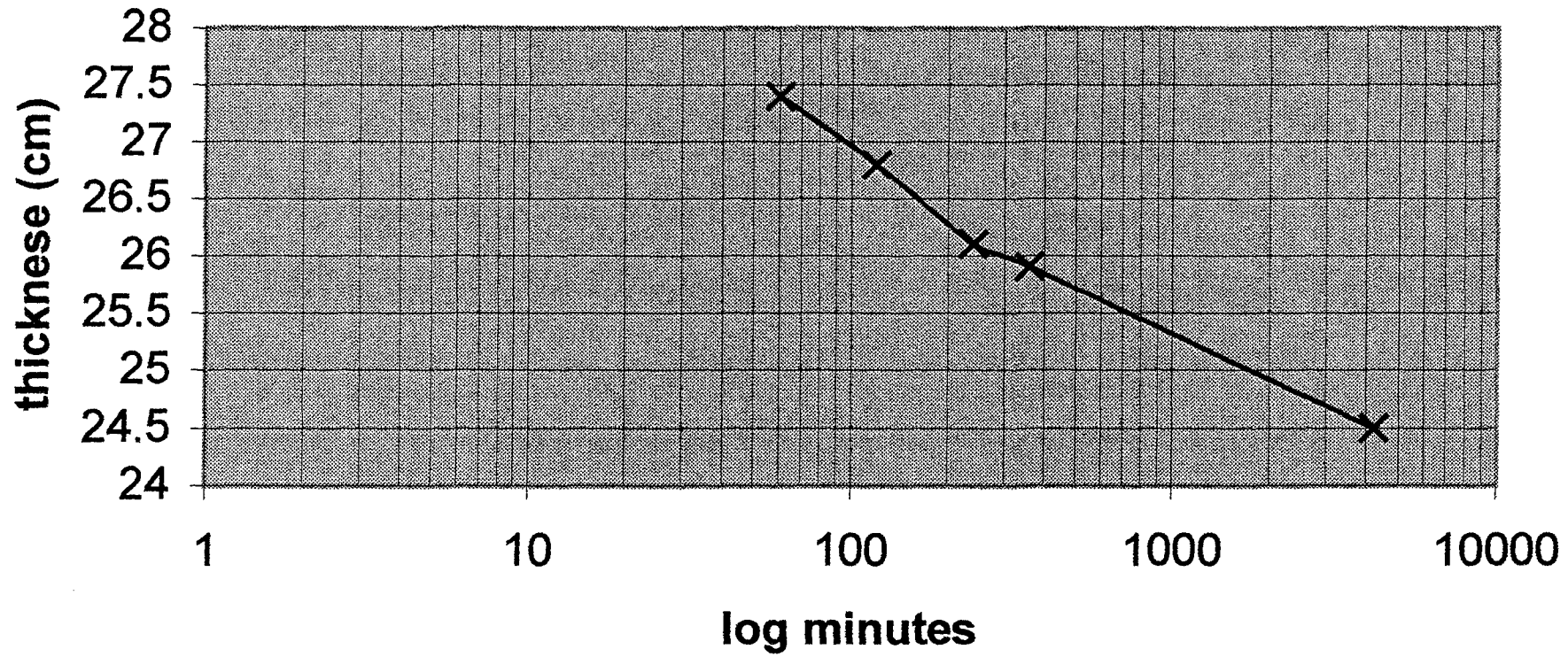
$k = \text{constant}$

$$= k \frac{(24.5 - 15.2)}{\log \left(\frac{9.99}{4.91} \right)}$$

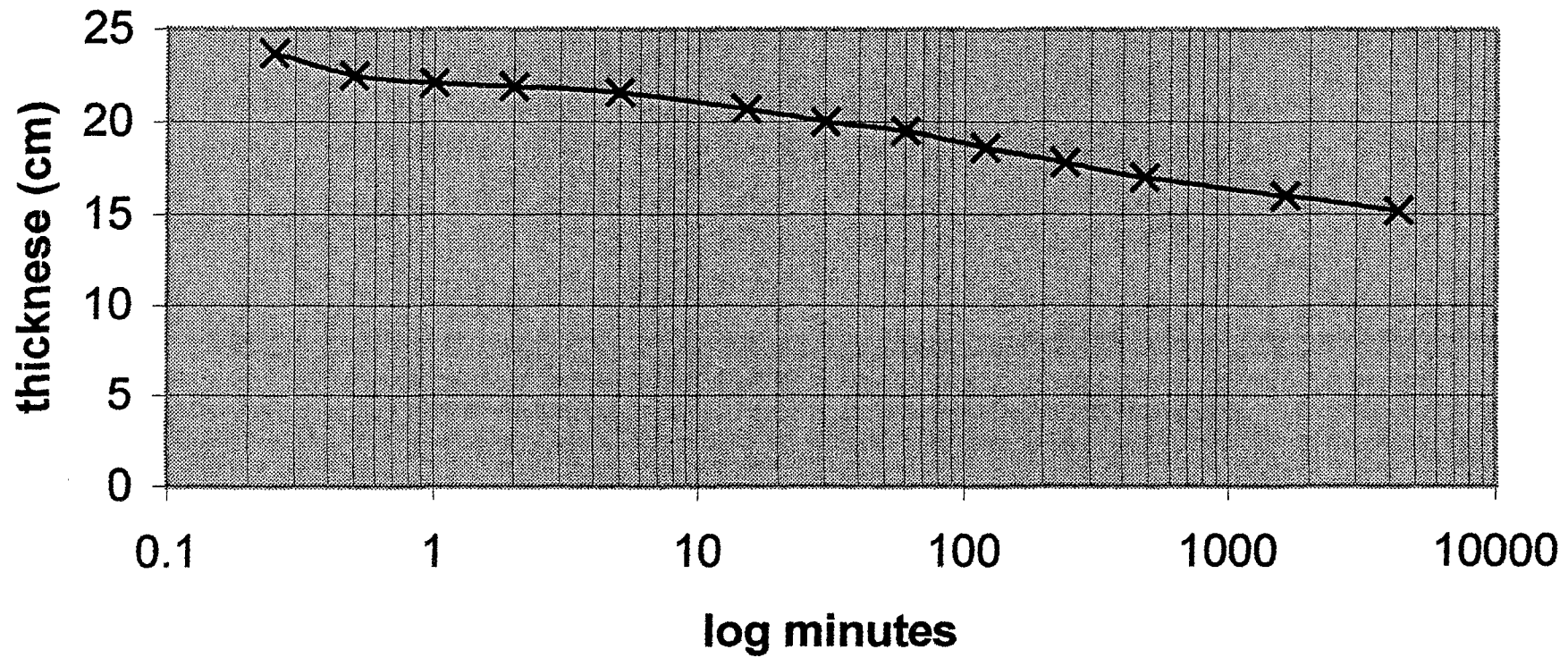
$$= k \left(\frac{9.3}{0.306} \right)$$

$$C_c = 30.39 k \text{ cm}^3/\text{N}$$

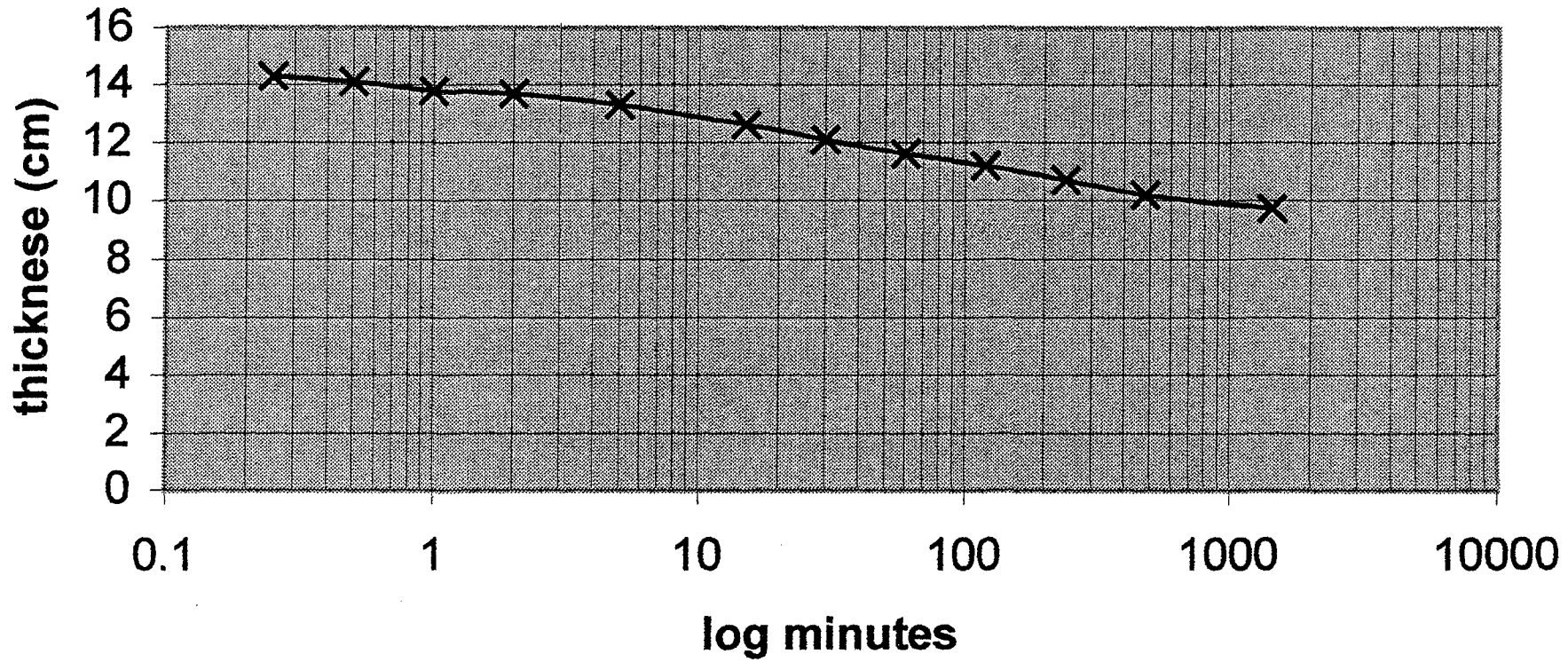
load at 4.91 kN/m²



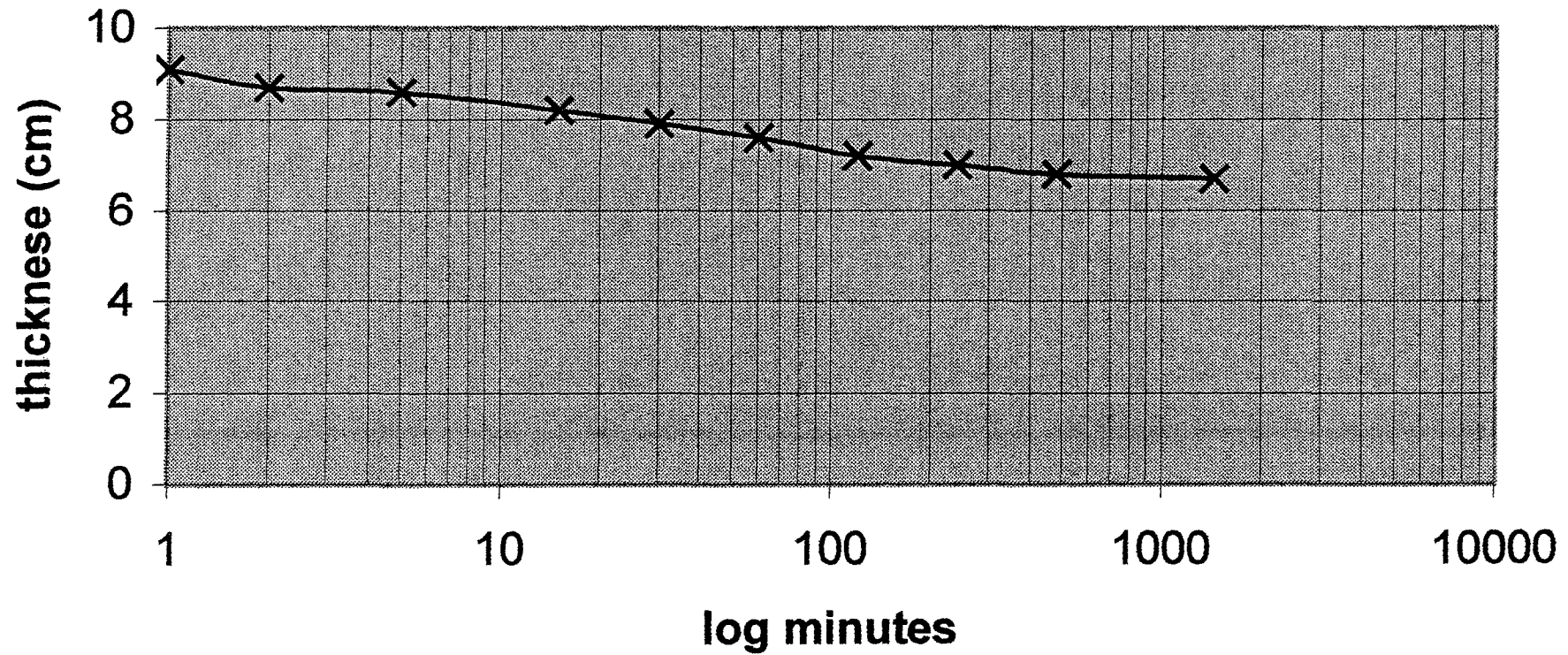
load increment from 4.91-9.94 kN/m²



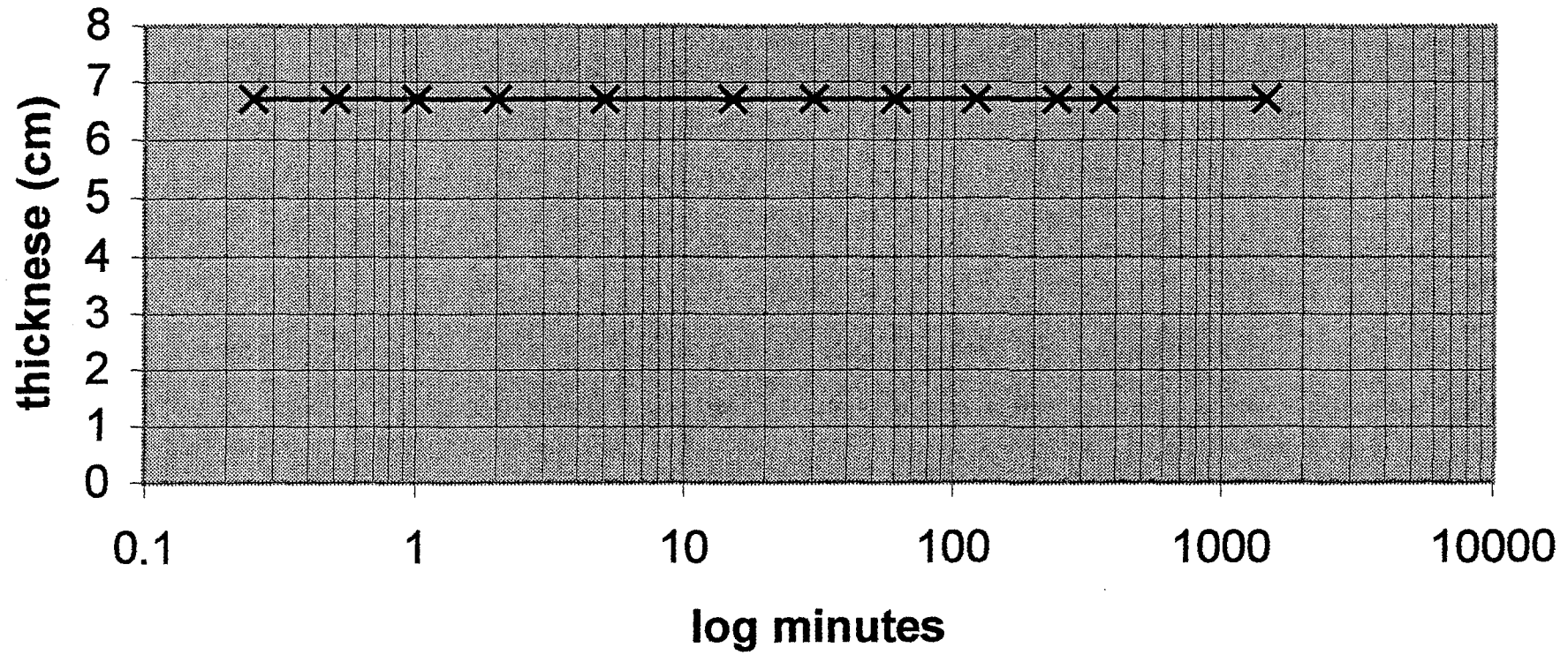
load increment from 9.94-20.1 kN/m²



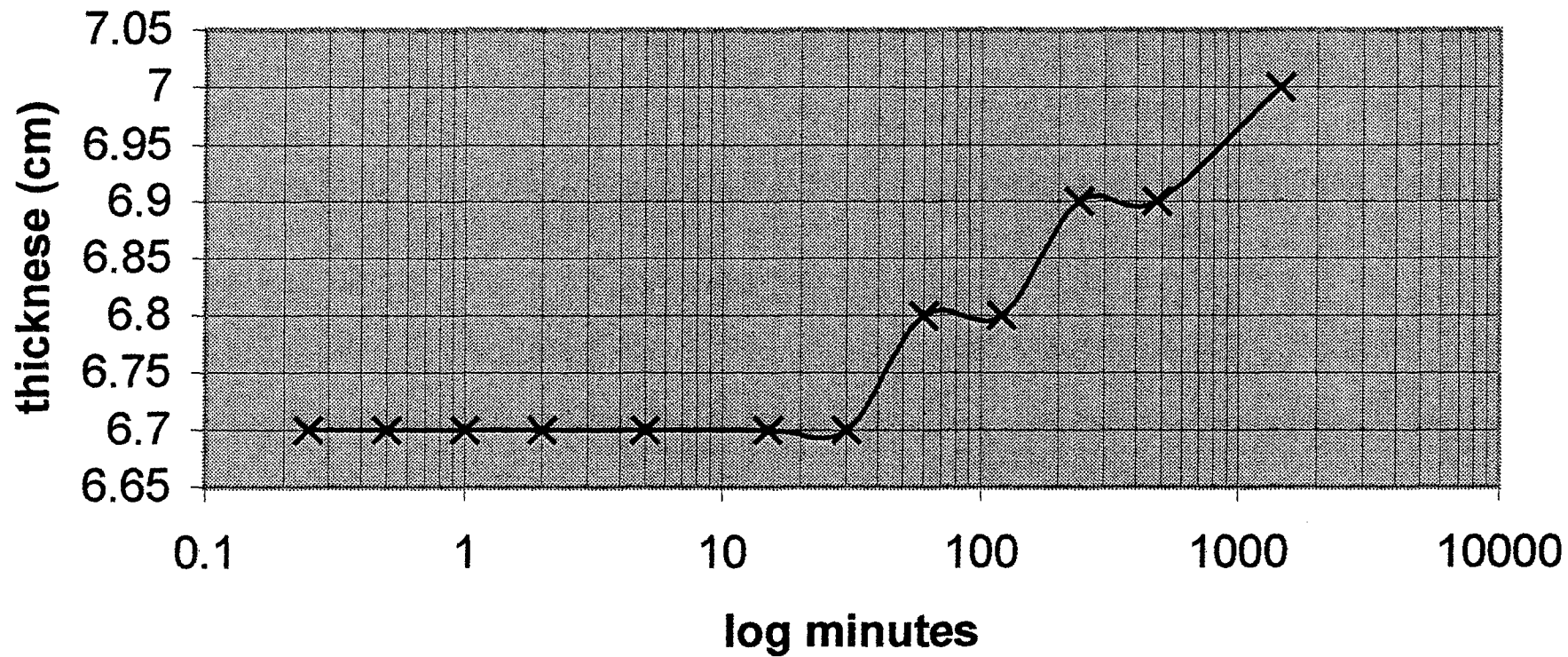
load increment from 20.1-40.5 kN/m²



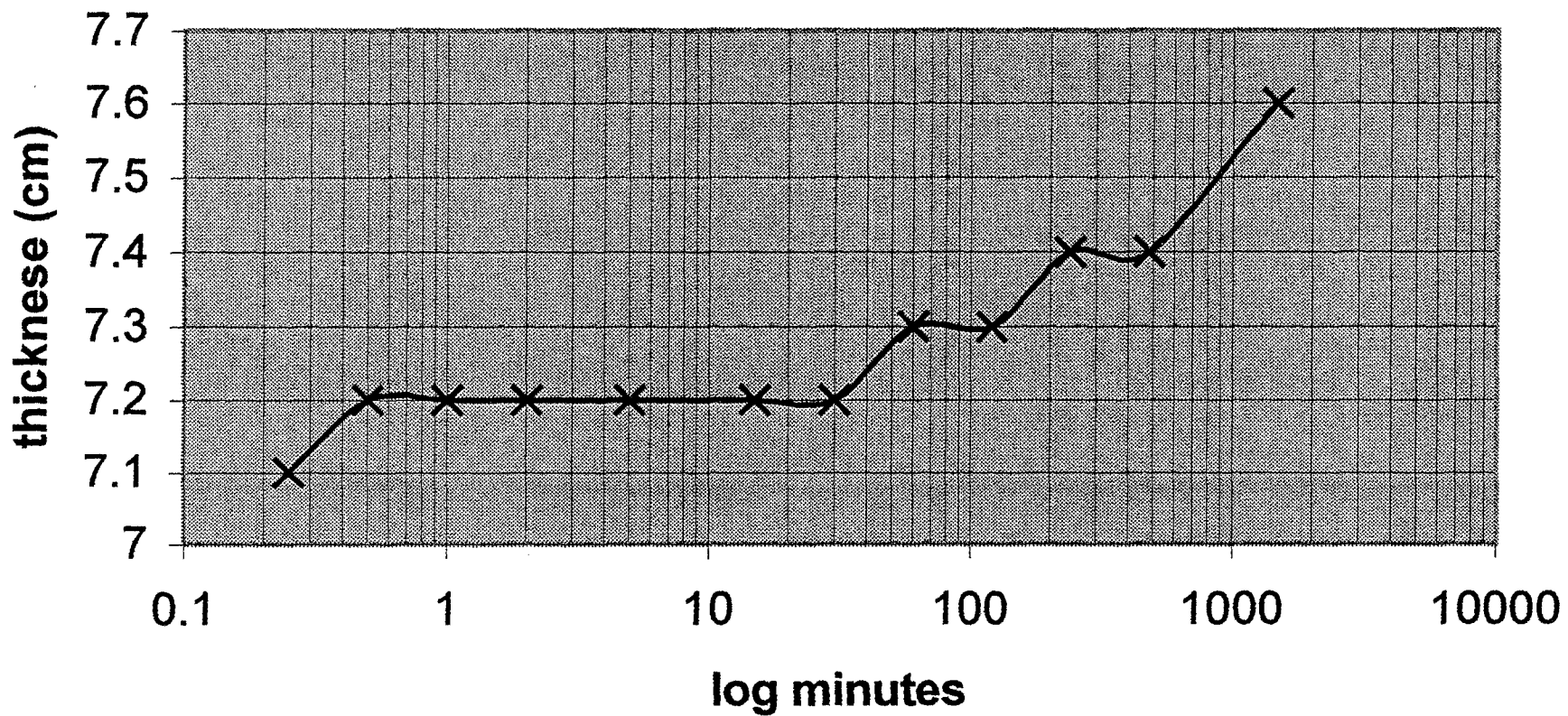
load reducing from 40.5-20.1 kN/m²



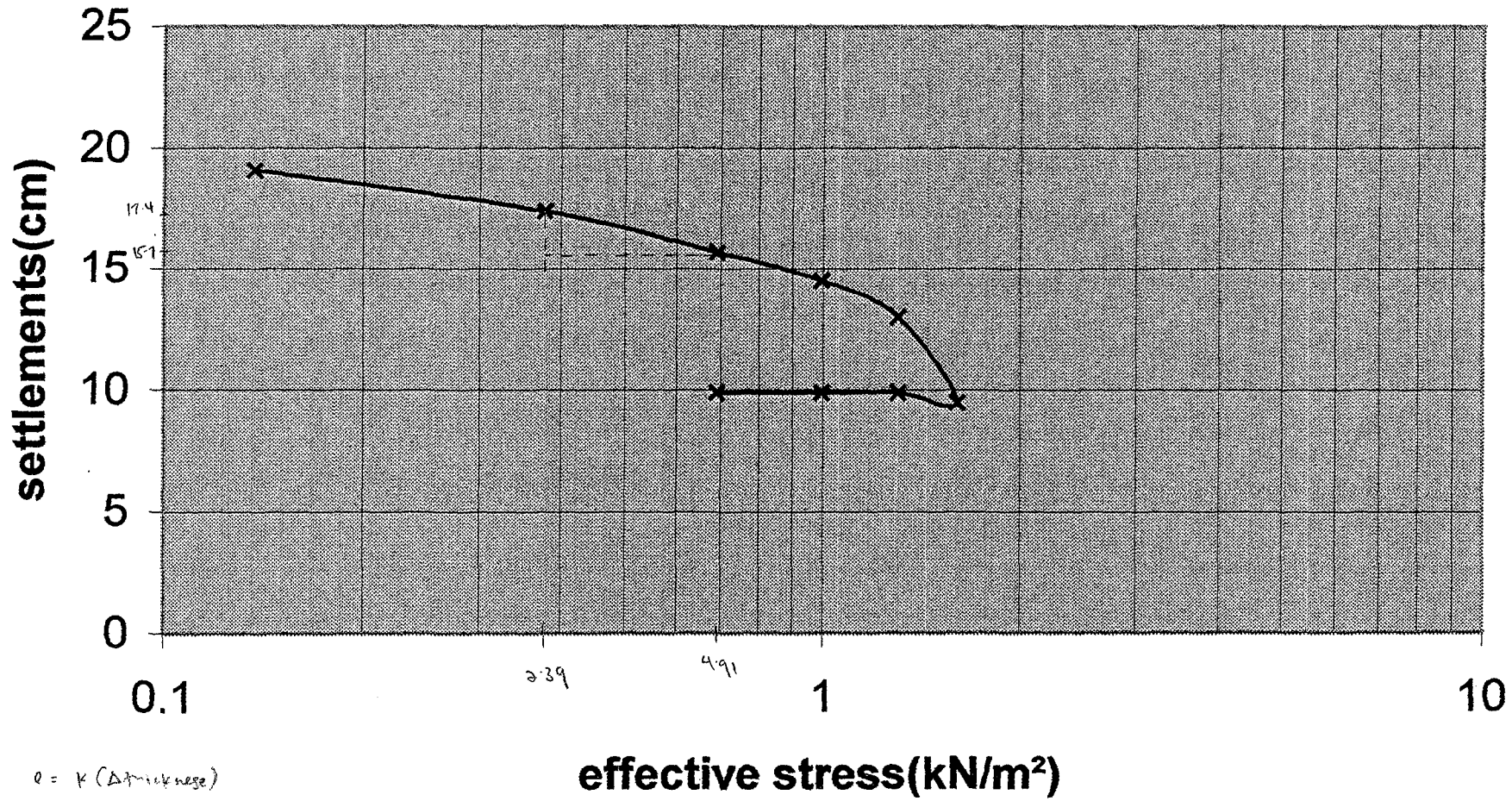
load reducing from 20.1-9.94 kN/m²



load reducing from 9.94-4.91 kN/m²



rice

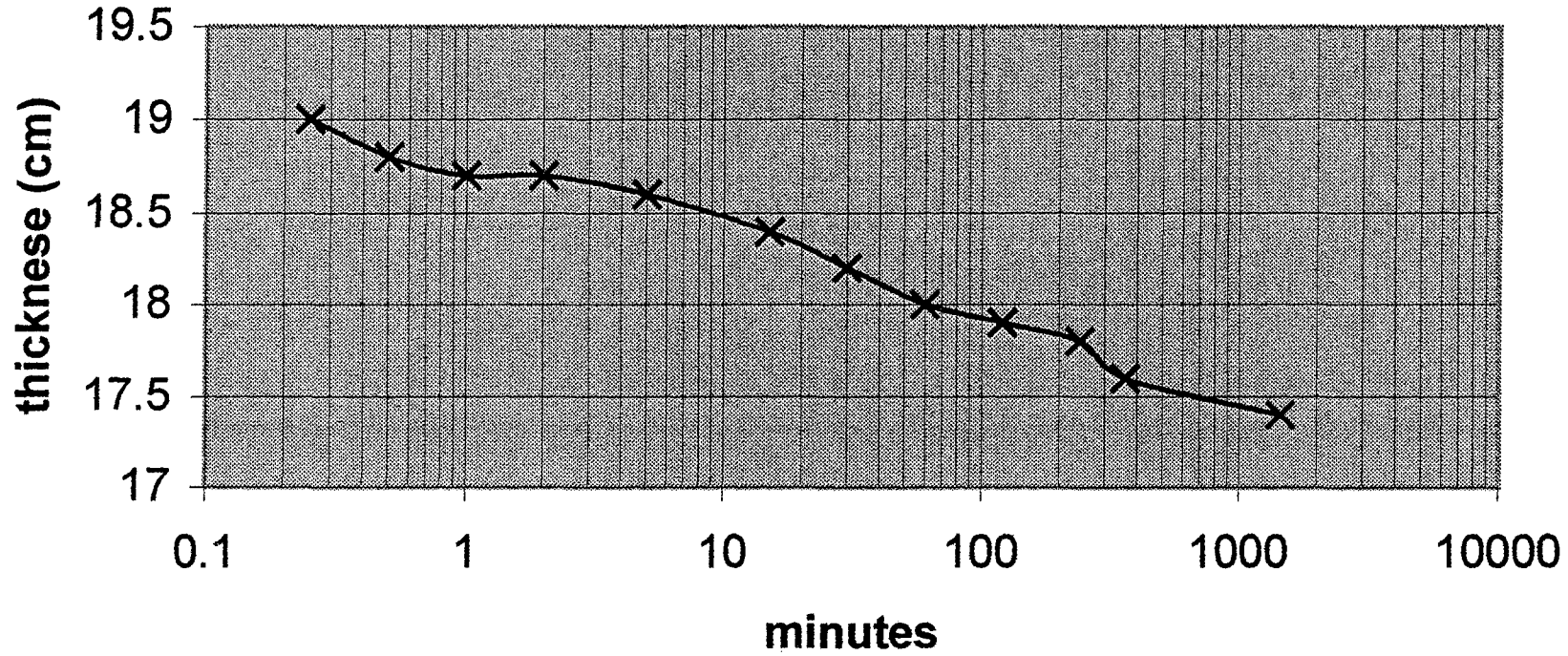


$$s = k (\Delta \sigma \cdot \text{thickness})$$

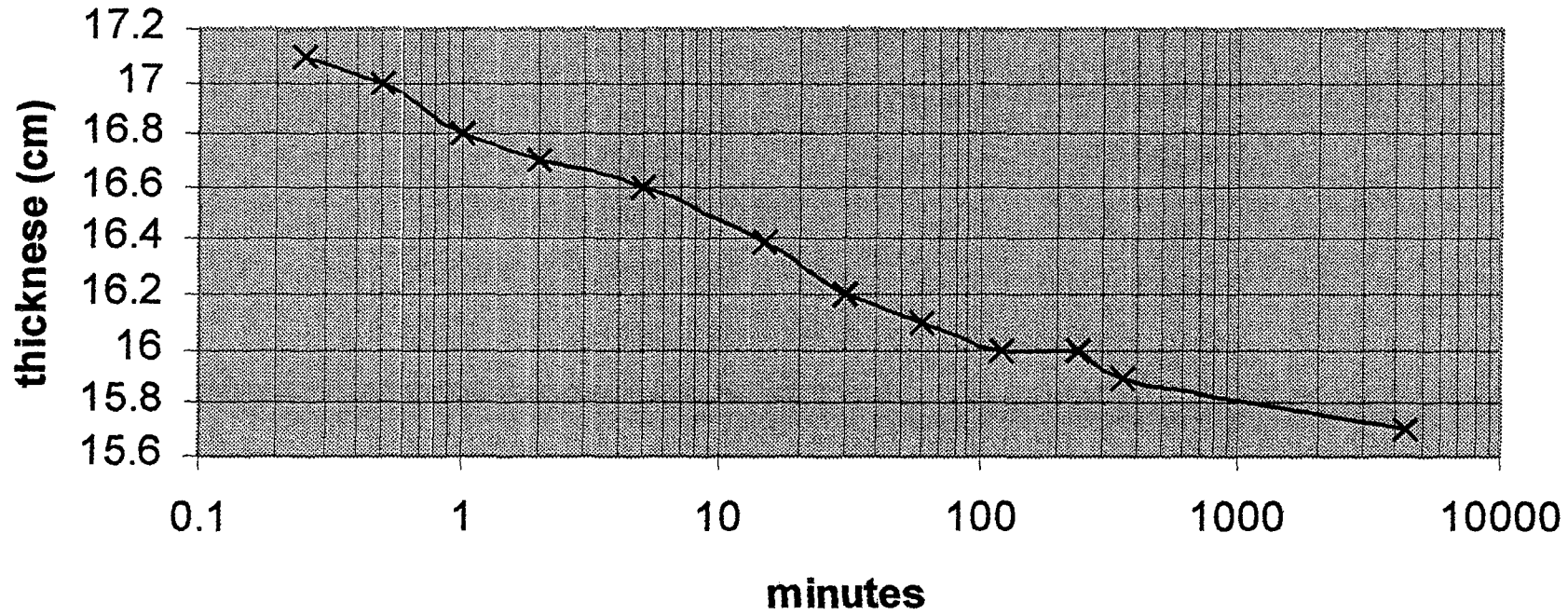
$$c_c = \frac{\Delta s}{\Delta \sigma}$$

$$= k \frac{\Delta s}{\Delta \sigma} \rightarrow k \frac{17.4 - 15.7}{\log\left(\frac{4.91}{2.39}\right)} = \frac{k(1.7)}{0.313} = 54.36 \text{ cm}^2/\text{kN}$$

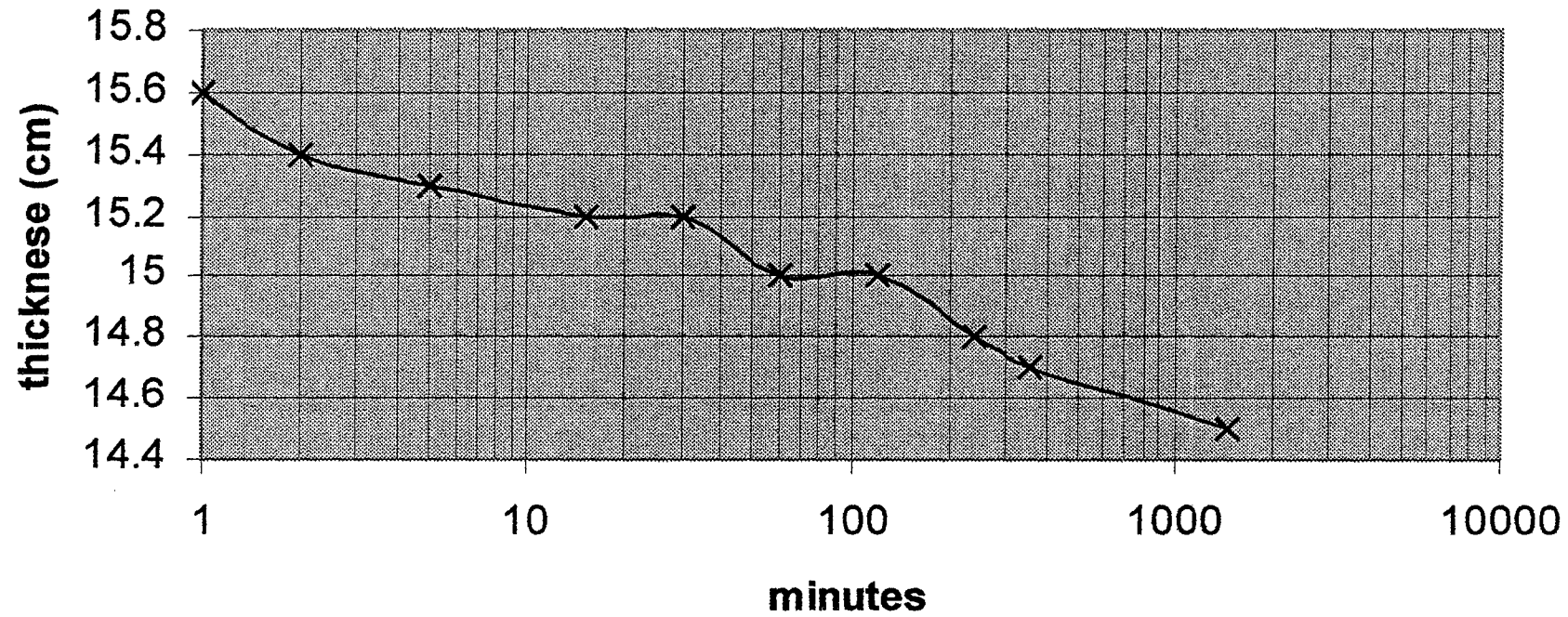
load increment from 1.37-2.39 kN/m²



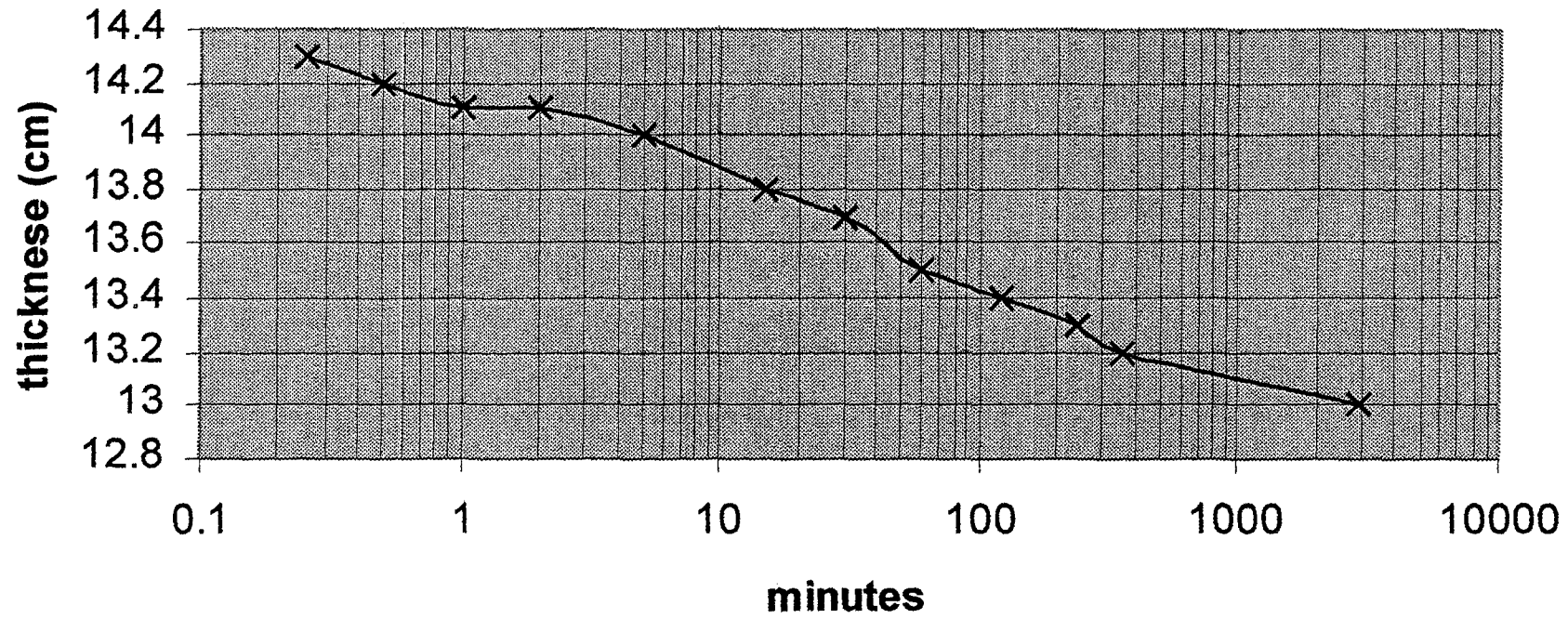
load increment from 2.39-4.91 kN/m²



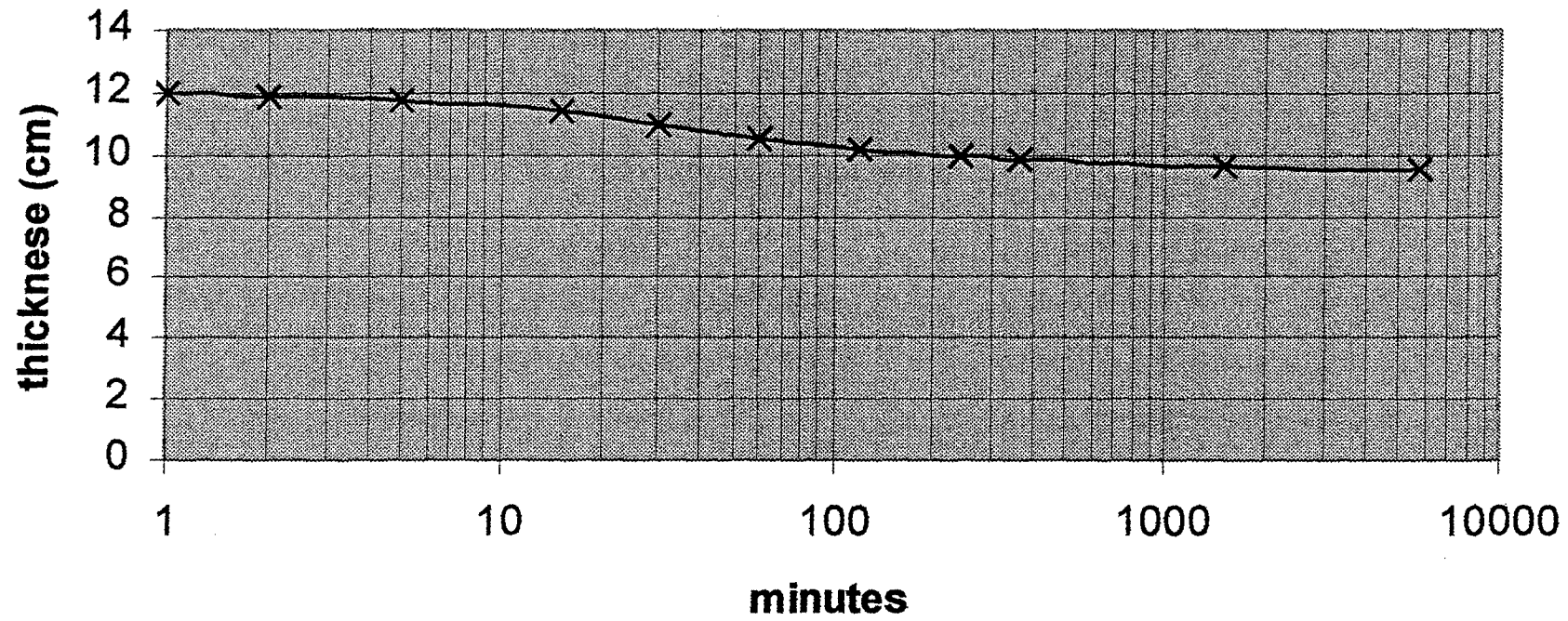
load increment from 4.91-9.93 kN/m²



load increment from 9.93-20.0 kN/m²



load increment from 20.0-40.12 kN/m²



load reducing from 40.12-20.0 kN/m²

