SiTek®
ELECTRO OPTICS

Non-Contact

3/99

PEOPLE, PRODUCTS & NEWS

# PSD applications in Civil Engineering

Recent tragic events have brought into focus the instability of the earth-crust we live on. Designing and building earthquake-resistant structures is one important way of creating safer environment.

The SiTek PSD can be a helpful tool for this kind of civil engineering. PSD technology is well suited for instrumentation that can remotely and contactless perform static and dynamic displacement measurements of building structures.

A pioneer in this field is Robert Jenzer, who twenty years ago developed a measurement method of testing in civil engineering. The result was the OCULUS system sold by Jenzer AG in the late 70's.
This instrument was intended for remote measurement (up to 300m) of two-dimensional displacement.

That this instrument was developed in Switzerland is no coincidence. This country is for the most part a mountainous country. Approximately 50% of the land is covered by the Alps and lies more than 1000m above sea level. It is therefore not surprising that many tunnels and bridges are necessary in the building of Switzerland's roads and railways. The corresponding Swiss standard specifies that loading tests are to be performed on all bridges having a span greater than 20m. The OCULUS was designed to facilitate these measurements by remotely probing load-induced displacements of reinforced and prestressed concrete structures.

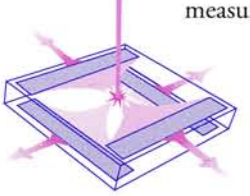
## The OCULUS system

The OCULUS system consists of

- a laser emitter
- a reception camera with a SiTek PSD
- an electronic signal processing unit.

The laser source serves as the measuring basis for the point to be measured. The laser beam is aimed at the PSD receiver and any minute movement of he receiver module relative to the stationary laser beam will be recorded.

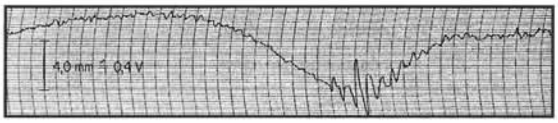
Measurements are taken at a rate of 8000 Hz and the measuring resolution is 0,2% of the measuring range. Since the laser system generates its own measurement basis optically, it can be installed practically independently of the topographical conditions. In many cases it affords the only opportunity to measure the dynamic diplacement at the characteristic point of a structure.



## Some typical applications

### *Bridge flexure measurement*

In the summer of 1979 the Swiss Federal Laboratory for Materials Testing and Research conducted static and dynamic load tests on the Niederhofen Reuss Bridge (national highway N2). The JENZER OCULUS proved in this case to be a valuable aid for quick, uncomplicated measurements at different locations.



**The bridge flexure resulting from a 16 tons truck**

**Vibration measurements of bridge supports**

During the building of the Ganter Bridge over the Simplon pass the fundamental frequencies and damping of the free-standing support piers needed to be determined. Using conventional methods for these measurements would have been impossible and instead the OCULUS was used.

Here the system was set up to measure the frequency and damping of a 148 m high free-standing pier with cantilevered beams on both sides of the pier but before connecting them with the corresponding cantilever on the adjacent pier. The receiver was mounted at the pier head and transmitter was positioned 220 meters away on the opposite slope along the old Simplon road. The pier and its cantilevers was pulled from its neutral position by means of jacks and wire cables which deflected the support 40 mm. The free oscillatory process was initiated by cutting the cables. The test record showed that the fundamental frequency was 0.14 Hz with a damping of 4 minutes.

**Track motion measurements**

Another popular application suitable for the OCULUS is ***measurement of railway track motion*** under load. Such measurements were for example conducted during reconstruction of the Bilten-Reichenburg railway line in Switzerland. Test measurements concentrated on horizontal and vertical motion as well as the vibration frequency.
A Re4/4 II locomotive (mass 80 tonnes) travelling over the instrumentation point at speeds up to 140km/h was used for the load test.

# Japanese-style Conference in Stockholm

Nobody at SiTek could believe that there existed such a conference hotel just on the outskirts of Stockholm; a very unique place indeed where SiTek held an important staff conference. 10 people joined the Kick-off Conference. We all slept in traditional Japanese-style rooms.

Mickey Fukui, M.D. started our conference by giving a general presentation and a number of group discussions according the themes that were chosen followed. Everyone felt that he/she was the most important member of the company contributing towards our common goal. We then took a chance to bathe ourselves in a Japanese-style bath for relaxation. During our stay there we were always wearing Yukata. We all vowed that the 1999/2000 financial year would be even more successful for SiTek than the previous one.

## Jeanette Jernberg

My name is Jeanette Jernberg and I'm 21 years old.
I left college last year where I studied computer programming for 3 years in Uppsala. Since I left college I have worked at a computer company where I was mounting and testing computers.
At the end of March this year I started at SiTek in production. The job is varied and interesting and I'm glad to be working for SiTek.

In my free time I like to play basket ball and to socialize with my friends. During the summer I like to take my mountainbike out into the forests.

Visit our home page at:
**www.sitek.se**

# SiTek's renowned Customer Support Strengthened

The following personnel are managers at SiTek who form its customer support team and are ready to provide the fastest and most appropriate help to our valued customers and dedicated distributors. SiTek assures you that you will always receive prompt service, thereby benefiting from our expertise in PSD technology.

| name | title | responsible area | e-mail | direct tel no. |
|---|---|---|---|---|
| Lars Lindholm | R & D mgr | technical | lindholm@sitek.se | +46(0)31 340 03 43 |
| Conny Nordin | Production mgr | production | nordin@sitek.se | +46(0)31 340 03 34 |
| Katrin Lindén | Administration mgr | marketing/sales & administration | linden@sitek.se | +46(0)31 340 03 33 |
| Mickey Fukui | Managing Director | sales/marketing | fukui@sitek.se | +46(0)31 340 03 31 |

In addition, the following administration personnel are at your disposal too:

| | | | |
|---|---|---|---|
| Madeleine Lageson | administration | lageson@sitek.se | +46(0)31 340 03 32 |

# SiTek's PSD-school

## SECTION 14 by Lars Stenberg

In chapter 13 we studied several of the most common metals and alloys that are used in the construction of electro-optical instruments. This chapter will focus on optical glass.

### Optical glass

The first more systematic study of how - time after time - it would be possible to produce molten glass with the same refractive index and dispersion[1] was carried out by the German scientist Joseph von Frauenhofer starting in 1811. However, it was Ernst Abbe who, together with Otto Schott, really laid the foundations for the optical glass types that are in use today by starting - in 1879 - to develop different optical glass qualities with properties that were unsurpassed until then.

Through adding different elements in the molten glass it is possible to vary the refractive index and dispersion of the finished glass within wide limits. Through adding the rare earth metal lanthanum it is possible e.g. to produce high refractive optical glass with low dispersion. Nevertheless, all these exotic additives of different elements sometimes meant that the finished glass acquired certain undesirable properties such as the formation of small bubbles inside the glass as well as the fact the glass did not stand certain chemicals and - at times - even water.
Table 1 below shows the refractive index of certain different types of optical glass.

| Glass designation | Glass number | $n_F$ | $n_d$ | $n_C$ | $\nu_d$ |
|---|---|---|---|---|---|
| FK51 | 487845 | 1.49056 | 1.48656 | 1.48480 | 84.47 |
| BK7 | 517642 | 1.52238 | 1.51680 | 1.51432 | 64.17 |
| F2 | 620364 | 1.63208 | 1.62004 | 1.61503 | 36.37 |
| SF6 | 805254 | 1.82775 | 1.80518 | 1.79609 | 25.43 |
| SFL6 | 805254 | 1.82780 | 1.80518 | 1.79609 | 25.39 |

The alphabetical designation in the table above indicates different wavelengths. This began by using upper-case letters and when this was insufficient it continued with lower-case letters. Since there are so many different spectral lines there was a gradual move to indicating the wavelengths of the spectral lines in nm ($1\text{nm} = 10^{-9}\text{m}$). In the table below the alphabetical designation is shown for certain known spectral lines.

| Letter | Wavelength in mm | Spectral line |
|---|---|---|
| F | 486.1327 | blue hydrogen line |
| e | 546.0740 | green mercury lin |
| d | 587.5618 | yellow helium line |
| D | 589.2938 | yellow sodium line |
| C | 656.2725 | red hydrogen line |

$n_d$ thus indicates the refractive index for the glass in question at a wavelength of 587.5618 nm. The dispersion or colour spread for an optical glass is normally indicated by means of the inverted relative dispersion, also called Abbe's $\nu_d$ value which is defined as

$$\nu_d = \frac{n_d - 1}{n_F - n_C}$$

Since the refractive index for most optical glass varies between 1.5 and 2 then this means that the numerator in the definition of Abbe's value above is of the magnitude of 0.5 to 1. If an optical glass has large dispersion this means that there is a larger difference between $n_F$ and $n_C$ than if the glass has low dispersion. This means that if the optical glass has a high dispersion then the numerator that varies between 0.5 and 1 should be divided by a greater number than if the glass has a small dispersion. This means therefore that a glass with a low $\nu_d$ value (25-30) has a large dispersion and a glass with a high $\nu_d$ value (65-70) has a small dispersion or colour spread.

The glass designations above are obtained from the German company Schott's glass catalogue. There are some ten or so other optical glass manufacturers in the world and their glass designations and catalogues show great similarities with Schott's glass catalogue. In addition, it is customary to designate the different glass types with a 6-figure number whose first three numbers are the first three decimals of the refractive index of the glass in question and whose last three numbers are the first three figures of Abbe's $\nu_d$ value for the glass in question.

On grounds of historical tradition it is customary to differentiate between crown glass and flint glass. The dividing line between crown glass and flint glass in terms of definition is to $\nu_d$ found at the $\nu_d$ value 50. In general, it is the case that crown glass is harder than flint glass which means that it is not as easy to scratch optical components manufactured of crown glass.

When modern optical design programs are used there are frequently several different glass catalogues stored in the program and there are optimisation procedures which mean that the program attempts to optimise the optical design through searching for optimal glass combinations.

---

(1). If two prisms are produced with the same geometry but from two different optical glass qualities, one with high dispersion and the other with low dispersion, this means that the prism with high dispersion produces a broader spectrum than the prism that is made from glass with lower dispersion. Thus, dispersion is a measurement of the colour spread of the glass.

Frequently, this optimisation ends in different extreme positions so far as glass selection is concerned. For example, as regards the glass FK51 in table 1 above there are many optical lens manufacturers that refuse to work on this glass. This is due to the fact that FK51 has a coefficient of linear expansion of 15.3 ppm compared with BK7 that has 8.3 ppm.

The coefficient of thermal conductivity for FK51 is 0.911 W/m·K compared with 1.069 W/m·K for BK7. What happens when one washes the FK51 glass during the different manufacturing phases is that if the washing water's temperature deviates too much from the FK51-glass's current temperature then it cracks on account of the unfavourable combination of high linear expansion co-efficient and poor heat conductivity. On the other hand there is no problem in manufacturing components of BK7-glass. This, combined with the fact that BK7 is relatively hard means that prisms and optical windows are frequently manufactured in BK7-glass. Nor do many optical lens manufacturers like to work on the SF6-glass in table 1 above. This is due to white stains on polished optical surfaces of SF-6 glass being easily formed if water ends up on the glass already after 10 to 20 minutes. In order to avoid this it is therefore necessary to dry the surfaces every time one finishes polishing and this takes time.
If, instead, one selects the somewhat more expensive glass SFL6 (see table 1) these problems are eliminated.

The price per kg of optical glass varies between USD 15 and USD 20.000. Therefore, it is important to check, at an early stage of the design process, that you have not included too expensive an optical glass. You should always try to get the optimum design by means of the most stable, bubble-free and least costly optical glass types.

I have specially taken up the aforementioned problems since it has happened more than once that designers of optical systems have presented a finished design that has entailed so many difficulties and costs in production that the designers have had to return to their computers and more or less start again from the beginning. My advice, therefore, is that it is always very sensible to contact the glass cutters that are going to manufacture the optics and consult with them at a very early stage on whether the glass combination in question offers any problems from a production viewpoint. One should therefore take the opportunity of enquiring whether the thickness of the centre and edges of the lenses entails any problems. If, for example, a negative lens is too thin in the centre then the glass may be elastic during the polishing and thereby make it impossible for the already polished surface to acquire a sufficiently precise spherical form. On the other hand, if a biconvex lens has too small an edge thickness then this entails that there is insufficient material when the lens is to be centred to finished size, since this operation is always carried out after both surfaces of the lens are ready polished.

The next chapter of the PSD school will be the last chapter in the series about how to design the optics and mechanics of a triangulation probe.
It will focus on problems caused by faulty mechanical design solutions.

Published by
SiTek Electro Optics, Ögärdesvägen 13A,
S-433 30 Partille, Sweden.
Tel: +46-31-340 03 30. Fax: +46-31-340 03 40.
Website: www.sitek.se
E-mail: info@sitek.se

SiTek®
ELECTRO OPTICS